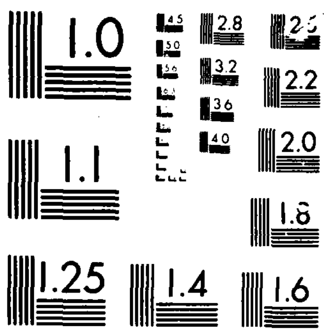
AD-A168 692 A RESEARCH PLANNING ASSESSMENT FOR APPLICATIONS OF ARTIFICIAL INTELLIGENC..(U) UNIVERSAL TECHNOLOGY CORP DAYTON OHIO W M HENGHOLD ET AL. JAN 86 1/3

UNCLASSIFIED AFWAL-TR-86-4018 F33615-83-C-5077 F/G 13/8 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.8
3.2
3.6
4.0

②

AFWAL-TR-86-4018

AD-A168 692

A RESEARCH PLANNING ASSESSMENT FOR APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN MANUFACTURING

DTIC
ELECTE
JUN 1 2 1986
S D
D

UNIVERSAL TECHNOLOGY CORPORATION
1270 N. FAIRFIELD ROAD
DAYTON, OHIO 45432

AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT PATTERSON AIR FORCE BASE, OHIO 45433

JANUARY 1986

INTERIM REPORT FOR PERIOD FEBRUARY 1985 - AUGUST 1985

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

MATERIALS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

86 6 11 054

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as, in any manner, licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may, in any way, be related thereto.

This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Roger D. Griswold

ROGER D. GRISWOLD, Project Manager
Computer Integrated Manufacturing
Branch

Gerald C. Shumaker

GERALD C. SHUMAKER, Actg. Chief
Computer Integrated Manufacturing
Branch

FOR THE COMMANDER:

Vincent J. Russo

VINCENT J. RUSSO, Actg. Chief
Manufacturing Technology Division

If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization, please notify AFWAL/MLTC, W-PAFB, OH 45433 to help maintain a current mailing list.

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

AD-A168692

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; Distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFWAL-TR-86-4018
6a. NAME OF PERFORMING ORGANIZATION Universal Technology Corp. 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Materials Laboratory (AFWAL/MLTC)
6c. ADDRESS (City, State and ZIP Code) 1270 North Fairfield Rd. Dayton OH 45432	7b. ADDRESS (City, State and ZIP Code) Air Force Wright Aeronautical Laboratories Wright-Patterson AFB OH 45433
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F33615-83-C-5077
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
78011F			

11. TITLE (Include Security Classification) A Research Planning Assessment for Applications of (OVER)

12. PERSONAL AUTHOR(S)
Henghold, William M., Triscari, Thomas (Air Force Institute of Technology)

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Interim	FROM 850201 TO 850831	January 1986	211

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB. GR.
09	02	
13	08	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Manufacturing, Manufacturing Technology, Artificial Intelligence.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

ABSTRACT - The Air Force Wright Aeronautical Laboratories Materials Laboratory is charged with developing a research program for applications of Artificial Intelligence (AI) as it relates to manufacturing. As a part of program development, advisory input was sought from experts from industry, academia, and government. A structured methodology was employed which featured a top-down approach leading from concept level articulation, through application area goals and objectives, to project level detail. This report documents the effort in terms of providing methodological background, application area goals and objectives, and results obtained from project generation and assessment.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
Roger D. Griswold	513-255-7371	AFWAL/MLTC

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

BLOCK 11 Cont.

Artificial Intelligence in Manufacturing. (Unclassified)

PREFACE

This interim report describes work in support of the Air Force Wright Aeronautical Laboratories Materials Laboratory under contract F33615-83-C-5077 from February 1985 to August 1985. It is published for information only and does not necessarily represent the recommendations, conclusions, or approvals of the Air Force.

The Project Manager for the Air Force was Roger D. Griswold, Computer Integrated Manufacturing Branch, Manufacturing Technology Division. This report was prepared by the Universal Technology Corporation, Engineering Services Division, Dayton OH. The Principal Investigators and authors were Dr William M. Henghold of Universal Technology Corporation and Capt Thomas Triscari, Jr., of the Air Force Institute of Technology.

This report documents a group process and in large measure, it reports the efforts provided by the participants of a workshop held 31 July 1985 to 1 August 1985. The authors wish to thank all workshop participants for their contributions to this effort. In particular, we wish to thank the sub-panel members for their support in laying the goundwork. These people are George Chryssolouris, Mark Cutkosky, Bob Didocha, Ed Fisher, Geoff Goldbogen, Don Hillman, Dave Liu, Bob Lorenz, Dennis O'Conner, Pete Papas, Ben Peek, Andy Tang, Dave Yancey, and Bob Young. Their's is the creative effort.

LIST OF FIGURES

FIGURE #	CAPTION	PAGE
1	Unit Process Frequency Distributions	10
2	Manufacturing Systems Frequency Distributions	13
3	I^2H Frequency Distributions	15
4	Frequency Distributions for Intelligent Software Development Assistant	16

LIST OF TABLES

TABLE #	CAPTION	PAGE
1	Demographic Recompilation	8
2	Unit Process Rankings	10
3	Manufacturing Systems Rankings	13
4	I^2H Rankings	15
5	Group Means from Workshop Feedback Survey	18

TABLE OF CONTENTS

SECTION	DESCRIPTION	PAGE
I.	INTRODUCTION	1
	1. Background	1
	2. Report Organization	2
II.	METHODOLOGY	3
	1. Overview	3
	2. Program Strategy and Goals	3
	3. Application Areas	4
	4. Ground Work Phase	5
	5. Preparation Phase	6
	6. Workshop Phase	6
III.	DISCUSSION	8
	1. Demographics	8
	2. Selected Results	9
	3. Closure	19
APPENDIX A	UNIT PROCESS PANEL RESULTS	A1
APPENDIX B	MANUFACTURING SYSTEMS PANEL RESULTS	B1
APPENDIX C	INTELLIGENT INFORMATION HANDLING PANEL RESULTS	C1
APPENDIX D	FORMS AND INSTRUCTIONS	D1

INTRODUCTION

1. Background

Artificial intelligence (AI) is concerned with translating the understanding of how humans acquire, organize, and use information. Two central goals have been to understand the principles that make intelligence possible and to make computers more useful. AI appears to have significant application potential to many important manufacturing problems, ranging from production planning and control processes to shop floor automation(s). The techniques and theoretical results from this young field of inquiry hold promise for significant advances which lead from prototypes to applications that will meet manufacturing user needs.

The Air Force Wright Aeronautical Laboratories Materials Laboratory is charged with developing a research program for applications of AI as it relates to manufacturing. The R&D program must span the manufacturing environment, including the design and manufacturing interactions, in a comprehensive manner and be thoroughly integrated with on-going activities. The latter includes AI efforts not directly related to manufacturing (such as the Strategic Computing Program) as well as non-AI pursuits that do relate to manufacturing (such as the Computer Integrated Manufacturing Program). While the Materials Laboratory is the Air Force Center for Manufacturing R&D Projects there is relatively little "in-house" expertise in AI techniques. Thus, the task facing the Laboratory Management was how to incorporate a rapidly developing technology (AI) into its on-going research programs.

Although the final structure of the R&D program remains a management responsibility, it was recognized that industry and academia should be encouraged to provide input in the form of recommendations to the program's content and timing. By obtaining advisory inputs from such experts, the eventual AI in manufacturing R&D program should minimize unintentional research duplication (i.e., "reinventing the wheel") and increase the chances of finding opportunities for synergism with other research efforts.

There were seve.al activities that the Materials Laboratory sponsored to initiate an AI in Manufacturing R&D Program. These were: an initial planning workshop for AI in manufacturing held 8-9 November, 1984; an assessment of AI applications to manufacturing, undertaken by members of the Industrial Automation Laboratory of Texas A&M University; and a study of the potential for in-house research activities undertaken by a select computer science advisory committee.

Of particular importance to this effort are the outcome and lessons learned from the November 1984 planning effort. Although this workshop did not yield any specific results for an AI in Manufacturing R&D Program, it had a number of positive attributes. There was a free and open exchange of information. The vocational composition of the approximately 75 attendees brought an excellent balance of academic, industry, and government perspectives to the discussions, and there was a definite feeling of commitment to the future. The outcome of this initial workshop highlighted the need for a follow-on activity with a more structured environment and

agenda to document goals and objectives and to drive below the concept level to specific projects.

It was decided that a second workshop, having more specified objectives, offered an excellent opportunity to build on past efforts. From an Air Force analysis, a framework emerged in the form of an overall strategy and methodology developed which called for significant pre-workshop preparation to support the follow-on activity. This report documents the methodology employed and provides the results obtained from the process.

2. Report Organization

The methodology employed in assessing AI needs in manufacturing involved concept definition, application area specific white papers that encapsulate the challenges of applying AI, project level detail, and statistical assessments of projects, coupled with expert commentary. The methodology is discussed in detail in Section II.

Section III presents a discussion of selected results. It includes demographic information, assessment highlights and commentary on both the methodology and the utility of the information captured.

The process utilized in obtaining the AI assessments started with a blank piece of paper and finished with completed workbooks for each participant. A completed workbook is found in the appendices to this report. Appendices A, B, and C give the results from the deliberations of the Unit Process, Manufacturing Systems, and Intelligent Information Handling (I^2H) Panels. Each contains panel specific white papers, assessment criteria, example projects, assessment statistics, and expert commentary. Instructions and copies of forms are contained in Appendix D.

METHODOLOGY

1. Overview

The underlying rationale in planning and developing an R&D program for AI in Manufacturing was the idea that the collective efforts, information, and knowledge from various experts are needed to achieve an integrated program. The R&D planning methodology developed sought to provide a structured approach for facilitating and coordinating the communication of the participants both before and during the second workshop. The primary objectives of the R&D program planning methodology were:

- narrowing "manufacturing" into more specific application areas including potential goals and objectives for each application area;

- generating a potential list of R&D projects for the application areas; and,

- obtaining an assessment of the utility of the application area candidate projects.

In order to achieve the preceding objectives, a phased approach was selected. The phases called for application area definition, a ground work phase, a pre-workshop participation phase, and the workshop proper. These phases or activities contributed in an incremental way to further defining and planning the AI in Manufacturing Program. Each phase was pursued under an overall program strategy and associated goals.

2. Program Strategy and Goals

Laboratory Management provided strategic guidance for structuring the Air Force R&D Program for AI in manufacturing. It provided the basic foundation and direction for further planning activities. The following represent some of the major goals to be achieved with the R&D Program.

1) The overall goal of the program is to develop and apply AI techniques to manufacturing in such a manner that aerospace system life cycle costs are lowered, productivity is improved, and manufacturing responsiveness is increased.

2) The program will be an integral part of the total Air Force and other government manufacturing efforts.

3) The program will have its primary focus on batch manufacturing specific needs. The nature of the need that calls for Air Force investment must be articulated for any project that is proposed.

4) The program will be balanced among near, medium, and long-term goals. There is a need to achieve a series of incremental gains as AI techniques are applied to recognized manufacturing problems. Some of the initial application oriented projects must produce tangible results to insure continuing and even increased support. There must be a careful weighing of problem complexity, potential gains, and the dollar/opportunity costs required to achieve the gains. At the same time, the program must support the basic research needed to provide the next generation of AI based solutions to manufacturing problems.

5) The overall strategy for the program will be built upon the balanced perspectives of academia, industry, and government and will include a combination of direct contract, in-house, and cooperative efforts; e.g., the Air Force proposed Research Institute for AI in Manufacturing. This combination recognizes the need to insure that AI efforts for manufacturing are supported across a broad base of industry, academia, and government. The combination also insures that there are vehicles for near and mid-term applications, as well as for more long-term projects. In addition, the combination insures program and project definitions are looked at from a variety of perspectives. Neither the Air Force, aerospace industry, or academic institutions can achieve maximum results by proceeding independently.

The above mentioned goals or principles provided a starting point or frame of reference required of any top-down approach to R&D program definition. As expressed by management, the goals, integration requirements, and need articulation, indicated a phased approach to project development and indicated a strategy that seeks synergism. The latter is important because although the activity is being lead by the Air Force, it is hoped the products will be applicable to a wide range of government, industry, and academic pursuits.

3. Application Areas

In a broad sense, manufacturing can be thought of as beginning with product design and ending with support and maintenance of the product in the field. Manufacturing can be conceptualized as consisting of an information processing system and two general functions: (1) creating and using the manufacturing systems and (2) producing the product with unit processes. The activities associated with defining all the resources, products, plans, processes, schedules, materials requirements, etc. fall into the manufacturing systems area. The actual making of the product is considered the manufacturing unit process operation. In other words, manufacturing systems plan, schedule and control the support and implementation of the actual production, whereas the unit process operations execute the plan and perform the actual production. Overlayed on this overall manufacturing activity is the information system that contains the manufacturing data and its current state, its past history, and its planned (or proposed) future. Information systems are contained in computer data bases, files, and expertise of people and are an abstract representation of the physical manufacturing operation.

It is recognized that definitional boundaries may overlap and that gray areas may exist in any partitioning of the manufacturing whole into application areas. However, with the above perspective in mind, application areas were chosen as unit processes, manufacturing systems, and intelligent information handling (I^2H).

4. Ground Work Phase

The ground work phase was the critical element in the overall methodology. A small number (4 or 5) of experts from industry and academia formed sub-panels for the unit process, manufacturing systems, and I^2H application areas. They undertook the arduous task of providing the structure for follow-on activities. To this end, they undertook the efforts required to:

1) Prepare a "White Paper" for each application area which gave an overview of the challenges and opportunities for the development and application of AI methodologies as related to the characteristics of the specific application area. These White Papers presented the state of technology as viewed from a unit process, manufacturing systems, or I^2H perspective, including design interaction. Prime impediments to progress were emphasized and possible solutions highlighted. The White Paper served as a general thought piece that set the tone for group interaction by describing the environment and highlighting problems.

2) Prepare a succinct statement of the application area goal and sub-goals. This statement was application area specific in consonance with the overall goal of the program.

3) Prepared objectives that support the goals in an integrated, time-phased manner. These objectives focused on coordinated activities at both the basic and applied research levels, as well as those oriented toward near-term implementation.

4) Prepare examples of typical projects that support the thrust area goals and objectives. The examples typified that which was expected to emerge during the preparation phase. They detailed the "what" in terms of specific projects that build the body of AI knowledge, and the "why" in terms of a recognized manufacturing need and expected payoff. They presented an approximate time frame and resource requirement for project completion and demonstration. Project descriptions were limited to two pages and to a standard format.

5) Provide recommendations for proposed criteria for use in project assessment a J for eventual project selection.

During this phase, no requirement was made for standardization across the sub-panels as related to white paper content, goal/objective congruence, or criteria definition. This freedom was allowed in recognition of application area differences in terms of technology needs, of the advisory nature of eventual workshop products, etc.

The white papers, goals, objectives, criteria, and example projects are contained in Appendices A through C.

5. Preparation Phase

The results of the sub-panel activities (ground work phase) were integrated with other materials and placed in a workbook format. The workbook contained a concept/strategy section, a section for each application area which consisted of the white papers and 4 to 5 example projects per application area, and an instruction section. The workbooks were mailed to participants approximately 6 weeks prior to the start of the workshop. Potential participants were asked to provide feedback on the workbook contents. This feedback was solicited to allow for definition debate, disagreements as to the prime impediments progress, etc.

Proposed projects were solicited for workshop assessment. Individuals desiring to attend the workshop were encouraged to submit a project as their "ticket for admission". These projects were submitted on a two-page description form and were treated anonymously. The form provided for definition of proposed application area (i.e., Unit Process, I^2H, etc.), a descriptive title, problem definition/project objective, project description/approach, importance to manufacturing, potential payoff, contribution to science and technology base, project duration, major milestones, resource requirements and project classification in terms of basic research, exploratory development or manufacturing technology/advanced development. Definitions were given for all terms. Adherence to the form facilitated eventual assessment of the projects but constrained the level of detail available. Instructions and copies of the project description form are found in Appendix D.

Inputs from the participants were compiled and, where possible, fed back to them prior to the commencement of group activities at the workshop proper. This allowed for detailed study of projects in a pre-meeting participation mode.

6. Workshop Phase

The workshop was the primary session for final refinement and subsequent documentation of all preceding efforts. It was held on 31 July and 1 August 1985 in Dayton, Ohio. The two-day workshop activities centered on a series of facilitated project assessment rounds and supporting feedback.

At workshop check-in, each participant was assigned to one of three application area panels according to his or her preference. Once assigned, no "floating" was allowed. Thus, the workshop was actually a group of three concurrent workshops. Each participant was provided with an identification number. This number was used in all activities in order to provide for anonymity. Finally, the completeness of each participants workbook was checked and, where appropriate, late candidate projects were provided.

During the first assessment round, participants were asked to provide demographic information and assess the candidate projects for their respective panel. They assessed the projects, utilizing their workbook as a reference for project descriptions, against the panel specific criteria. A nine-point likert scalewas employed. The criteria utilized, scale, and associated anchors are in Appendices A, B, and C.

The results of the first assessment round were input to micro computers and statistics were compiled. These included group means, standard deviations, and frequency counts, on a criteria by criteria basis, for each project.

At the start of the second round, each participant was provided with a printout of his original assessments. Each response that was statistically different from the panel mean was flagged. Under the leadership of Air Force Panel Facilitators, the statistical feedback was used to identify areas of discussion, opinion revision or additional information. In those cases where individual responses were flagged as "outliers", participants were requested to reconcile or reassess in one of two ways. They could simply change their original assessment for the appropriate criteria. In the event they did not wish to change, they were requested to outline their reasons or rationale on a standard reconciliation form. This expert knowledge was captured and provided anonymously, to the group during the next round. Detailed discussion was discouraged during the second round until after the reconciliation process was complete.

Round three was essentially a repeat of round two with the primary difference being that facilitated discussion was encouraged. Both statistical feedback and outlier comments were provided to the panel participants. At the end of the discussion period, the panel experts were requested to reconcile or reassess based upon all information presented. They were free to reassess any response. Again, expert commentary was captured in written form as a required adjunct to numerical data.

DISCUSSION

1. Demographics

As a precursor to project discussion, a look at the demographics of workshop participants is in order. Table 1 shows a recompilation of the data obtained from the demographic forms. As can be seen from the employment data, industry participation was somewhat greater than academic, while government participation was considerably smaller than either. The latter is important in that anyone searching for the government bias in the analysis will not find it. In the AI interest portion, participants were allowed to select as many as three areas of interest. These data indicate that an expert system or knowledge representation bias may exist. These classifications are somewhat all encompassing, however. Note, in addition, that representation in some areas ranged from sparse to none. In the technical background section, of those selecting engineering, industrial engineers predominated with 9 of the 19 respondents. Finally, good representation of active programs for AI in manufacturing was obtained.

Table 1 Demographic Recompilation

CATEGORY	PANEL			TOTAL
	U.P.	M.S.	I²H	
CURRENT EMPLOYMENT				
ACADEMIA	6	11	5	22
GOVERNMENT				
Research	0	3	1	4
Management	0	2	1	3
INDUSTRY				
Aerospace Product	6	7	4	17
Computer Hardware	1	1	0	2
Computer Software	0	3	4	7
Non-Aerospace Product	2	1	0	3
AI INTEREST(S)				
Knowledge Representation	8	11	12	31
Artificial Vision	2	1	2	5
Pattern Recognition/Interpretation	1	1	4	6
Natural Language	1	1	3	5
Voice Recognition	0	0	0	0
Robotics	7	8	3	18
Knowledge Acquisition	4	13	2	19
Knowledge Based Systems (ES)	13	22	12	47
Other (specify)	2	9	2	13
TECHNICAL BACKGROUND				
Computer Science	1	7	6	14
Manufacturing Operations	1	3	0	4
Manufacturing Research	4	5	4	13
Knowledge Engineering	0	1	1	2
MATH/OR/MS	2	2	2	6
Engineer (specify)	7	10	2	19
ACTIVE PROGRAM FOR AI IN MANUFACTURING				
YES	10	21	10	41
NO	5	7	5	17

2. Selected Results

The wealth of information captured in the process of workshop preparation and conduct is contained in the Appendices. Selected results from each panel are presented which typify what is available. In the process of selection, some "good" projects as well as some "bad" projects are displayed. The terms good and bad are used with caution because, as will be pointed out later, they are only relative measures that apply to the sample projects as written. They may or may not apply to the concepts that underlie the examples.

Projects are best discussed in terms of numerical or statistical parameters and written comments taken mainly from the reconciliation forms. In selecting examples for discussion, a ranking of convenience has been employed. This was accomplished by applying an ordinality to the assessment statistics on a criteria by criteria basis. The project with the highest group mean for a particular criteria was ranked a number 1, the second was ranked 2, etc. In case of a tie, duplicate ordinate scores were given. No consideration was given to the magnitude of difference in mean values. (i.e., a delta of .01 was treated the same as a delta of .1). The method was quick, simple, and adequate for the purposes of this document. It ignores the potential for statistical nuances such as weighting and summing, etc. and should be considered as a rough ordering only. In no way should an absolute priority be assumed.

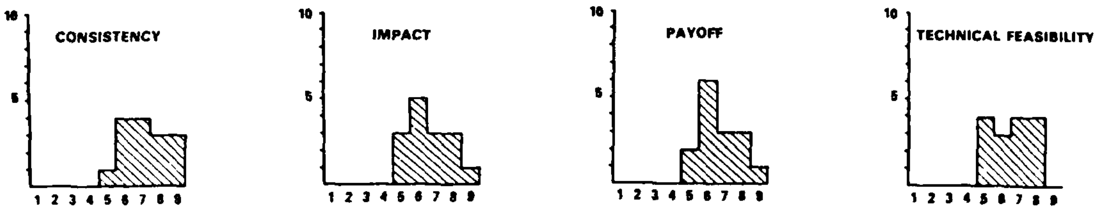
Applying the above methodology yields the results shown in Table 2 for the 15 projects considered by the Unit Process Panel. Figure 1 shows criteria specific frequency distributions for three highly rated projects from unit process deliberations. In this figure, the ordinate represents the number of responses and the abscissa represents the score on the 9 point Likert-type scale.

The "Expert System for a Design of Castings" Project (Fig. 1a) is a advanced development type project which, in essence, attempts to capture and use experience based design rules. The reconciliation (also called the outlier) forms contained no comments. The session notes indicated that the project is feasible, has good benefit and provides valuable experience. Concern was expressed about the adequacy of the modeling/processing science base, the general nature of the project, and the potential for duplication with another Government funded effort.

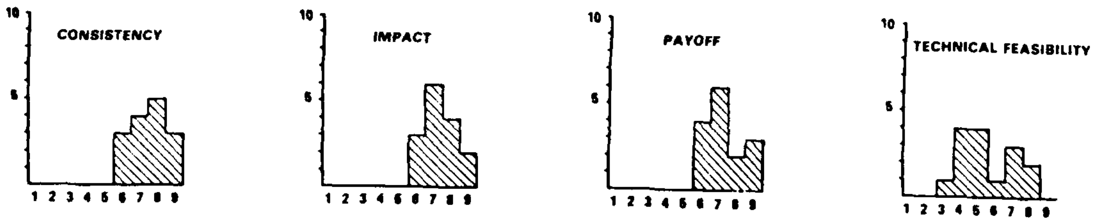
The "Rule Based Process Diagnosis" project (Fig. 1b) was classified as basic research. It is an attempt to go from process diagnosis to machine compensation. Outlier comments indicated that the definition/specificity of inspection knowledge should aid considerably in inference engine development, that the project does provide AI for the inspection end of manufacturing, and that an initial limitation to milling and lathe operations would increase project feasibility. Worry was expressed about the "doability" of adaptive control to recover from changes in structure. Session notes classified the project as one that was very good, worthy of expansion/refinement, and one that captures the "system's nature" of unit process steps. Again, concern centered on building an adequate experience base, portability, and customization problems.

Table 2 Unit Process Rankings

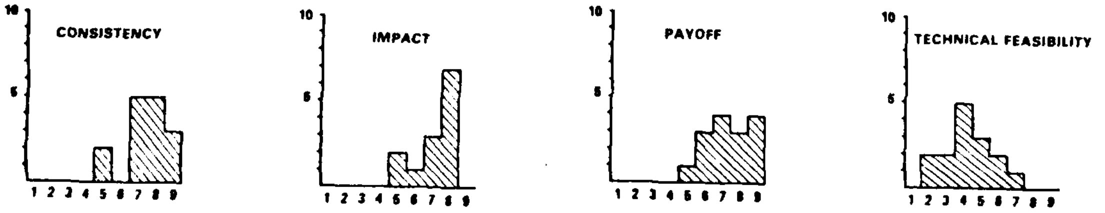
TITLE	CONSISTENCY	IMPACT	PAYOFF	TECHNICAL FEASIBILITY	RESULTANT
AI Configuration Design of Modular Fixturing Based on System Dynamics	10	11	12	7	12
A Grasping Expert for an Automated Machining Cell	12	15	15	6	14
Intelligent Knowledge Base System for Computer-Aided Analysis Packages for Unit Processing	13	14	13	4	13
Rule Based System for Intelligent Integration of Multiple Sensors in Assembly Tasks	5	4	3	7	4
Intelligent Processing of Composite Materials	6	7	6	4	6
Adaptive Planning for Automated Fab/Assembly Operations	2	1	1	12	3
A Teachable Unit Process	8	8	7	13	9
AI Technology for Real Time Machine Control	9	9	10	9	10
Intelligent Knowledge Based Systems to Provide Format Compatibility for Dissimilar NC Machine Control Combinations	14	12	11	1	11
Expert System for the Design of Castings	3	5	3	2	1
Machine Monitoring Expert System	11	10	8	3	7
Assembly Planning for Intelligent Robots	4	3	3	11	5
Distributed Intelligence Among Unit Processes	7	6	8	14	8
Rule-Based Process Diagnosis	1	2	2	10	2
AI for Process Design and Control Using High Speed Medium-to-Large Grain Parallel Computers	15	12	14	15	15



1a Expert System for the Design of Castings



1b Rule Based Process Diagnosis



1c Adaptive Planing in Fabrication

Figure 1 Unit Process Frequency Distributions

The "Adaptive Planning in Fabrication" Project (Fig. 1c) was classified as engineering development. This project is an attempt to provide process modification and contingency resolution through intelligent planning. The outlier comments indicated that the project was ambitious, technically difficult, and called for real time definitions in minutes or seconds. The facilitator notes indicate that the basic need is exception handling in the unit process sphere. There is considerable doubt about feasibility with respect to the availability of required modules for the project foundation and the learning situation of developing alternative plans.

The "AI for Process Design and Control Using High Speed Medium-to Large Grain Parallel Computers" Project was rated at or near the bottom for each criteria. It was viewed as having some important aspects but generally not a leverage project for either AI or manufacturing. This is pointed out by the following quotes taken from outlier comments.

> "Parallel computing very important for process modeling. AI content not a major factor."
>
> "Project has very good objective but does not appear applicable to the application of AI to manufacturing. I suggest the project be reclassified as part of a computer hardware/software development group."
>
> "The need for parallel processors is limited and industry is very slow to adopt radically different computers in manufacturing. The impact and payoff would be very high for activities such as high speed flight simulations but not manufacturing."
>
> "I see the project as highly oriented to generic parallel processing, not specific to AI in manufacture. Let Mathematical Sciences Division pay for it."

As can be seen from the above, the written comments generally contain a good deal of information relating to the assessment "why". For example, the top level strategy indicates that the need for any Air Force investment must be articulated for any project proposed. The following comments relate to this requirement as addressed to the "Intelligent Knowledge Base System for Computer-Aided Analysis Packages for Unit Processing."

> "This type of expert system has been done and will become widely available without USAF funding. Therefore, feasibility is very high. I don't feel that objectives or scope were met because analysis packages are limited to a small part (i.e., design) of the total manufacturing process."
>
> "This application of expert system is state-of-the-art already. The impact and payoff are limited to those groups that use the specific combination of analysis tools. It should be a commercially funded project. Hundreds of companies are already pursuing such projects. The Air Force should put its money elsewhere."

"There are already a multitude of commercial investments being made to address this area. The development is well under way and is not needing Air Force support."

Table 3 shows the rankings for the 20 projects considered by the Manufacturing Systems Panel. Highly rated projects are shown in Figure 2. The ordinate and abscissa have the same meaning as before.

The "Rule Based Process Diagnosis" Project (Fig. 2a) is the same project that was considered by the Unit Process Panel. The fact that the project was rated highly by both panels indicates some consistency between panels, even though there were definitional differences in criteria. It also lends credence to the feeling that a gray area exists between the manufacturing systems and unit process views of the manufacturing whole. While the statistics seem to indicate otherwise (e.g., better feasibility ranking by manufacturing systems than by unit process), the written comments indicate that manufacturing systems personnel are more concerned with the feasibility of this project. There was doubt expressed about the ability of rule based systems to produce effective explanations, the availability of data was questioned, as was the ability to understand the origin of defects. Feasibility for electronics or a rigid cell structure was considered adequate but one respondent indicated that feasibility coupled with manual control was "ridiculous." A previous meeting in the automotive industry pointed out the importance of this type project.

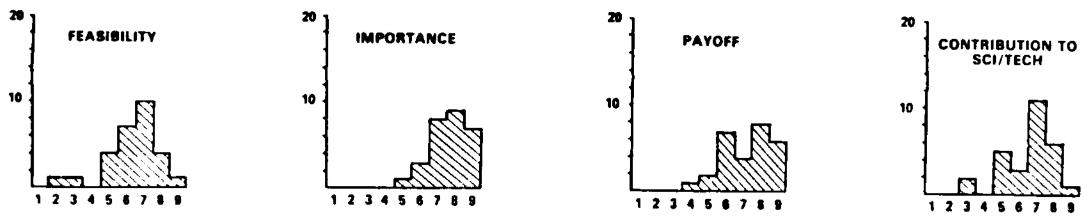
The "AI Applied to Mechanical Design" Project (Fig. 2b) was classified as exploratory development. Comments indicated that, as written, the project might be too all-encompassing, that relevance to CAD and data base development was doubted, and that the resource estimates were low. It was also suggested that AI for design advanced the state-of-the-art and that the project should be pursued under a proper heading of AI for design. It should be noted that the proposed project is presently on-going. The panel either missed that fact or considered that more resources required Air Force investment.

The "Generative Process Planning for Manufacturing" Project (Fig. 2c) was classified as basic research. It attempts to form an engineering design to manufacturing link by going from a coded description of part characteristics to a process plan. Comments expressed concern with the project's global nature (i.e., need to separate project into more definable parts such as feature extraction) and lack of specificity in the requirements area. Pre-workshop feedback was very sparse (only 3 inputs) yet the generative process planning was mentioned twice as an area with a great deal of industry initiated activity.

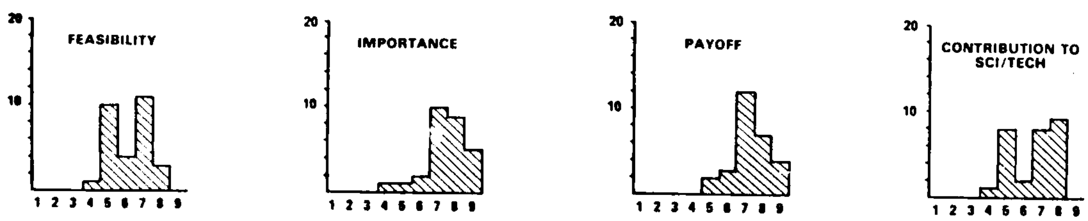
The "Expert System for Design and Analysis of Life Tests and Accelerated Life Tests" Project was classified as an advanced development type effort. It appears that the low ranking was a result of the manufacturing linkage being far from obvious. Panel members doubted the need, said it was design and not manufacturing, and doubted applicability to structural parts. Although no real analysis has been made, two quotes indicate that a project of this type may have significant importance to the electronics arena.

Table 3 Manufacturing Systems Rankings

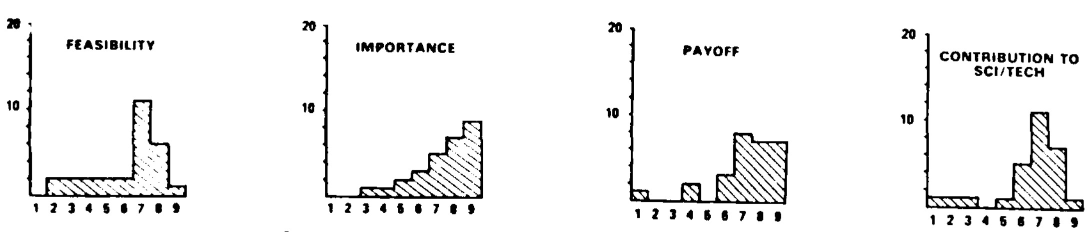
TITLE	FEASIBILITY	IMPORTANCE	PAYOFF	CONTRIBUTION SCI/TECH	RESULTANT
Material Handling Equipment Selection Expert System	1	19	19	20	16
Realtime Control of Cell-Level Batch Manufacturing	11	3	5	5	5
Engineering Change Management	19	8	10	18	14
Intelligent Shop Floor Scheduling System	15	5	4	10	8
Generative Process Planning for Manufacturing	5	3	2	2	3
Software Tools for System Scheduling	18	14	15	8	14
Expert System Based Simulation Model for Flexible Manufacturing Systems (FMS) Design	10	12	17	9	12
Utilization of Expert Systems in Manufacturing as Training Tools	13	18	18	19	19
Manufacturing Planning and Scheduling Using Integrated AI and OR Methodologies	11	15	15	6	11
Machine Monitoring Expert System	7	10	7	14	9
Shop Floor Scheduling with Resource Constraints	20	16	13	12	17
Designing Appropriate Scheduling and Control Systems	14	12	12	12	13
Intelligent Purchasing Support System	8	11	11	16	10
Expert Systems for Design and Analysis of Life Tests and Accelerated Life Tests	17	17	14	14	18
Integration of Statistical Capabilities, AI, and a Simulation Language	16	20	20	17	20
Rule-Based Process Diagnosis	3	1	2	2	1
AI Tools for Product Design for Economical Manufacture by Die Casting and Injection Molding	4	8	9	11	7
Artificial Intelligence Applied to Mechanical Design	5	2	1	1	2
Object Oriented Design Tool	2	6	6	2	4
Manufacturing Expert Planning System	9	7	8	7	6



2a Rule Based Process Diagnosis



2b AI Applied to Mechanical Design



2c Generative Process Planning for Manufacturing

Figure 2 Manufacturing Systems Frequency Distributions

"A critical issue in electronics manufacturing. Affects manufacturing floor space, cycle time, cost, performance in field. Resources do not match need. Have direct experience and am confident of estimate."

"Vital to electronics assembly and test based in personal experience in a number of companies and situations."

Table 4 shows the rankings for the 14 projects considered by the I^2H Panel. Highly rated projects are shown in Figure 3. The ordinate and abscissa have the same meaning as before. It should be noted that the I^2H Panel undertook a rewrite of their top projects during the workshop. The rewrite is considered in the discussion that follows.

The project entitled "An Expert System to Facilitate Design for Manufacturability" (Fig. 3a) was classified as exploratory development. The project attempts to use I^2H to provide manufacturability advice. There were no written comments on the outlier forms. As a result of the rewrite, the title was changed to "A Designers Assistant to Facilitate Mechanical Design". In addition, it expanded the scope beyond manufacturability to include inspectability, quality, reliability, and life cycle cost factors. It called for the use of ES and other computer technologies. The later term was not defined.

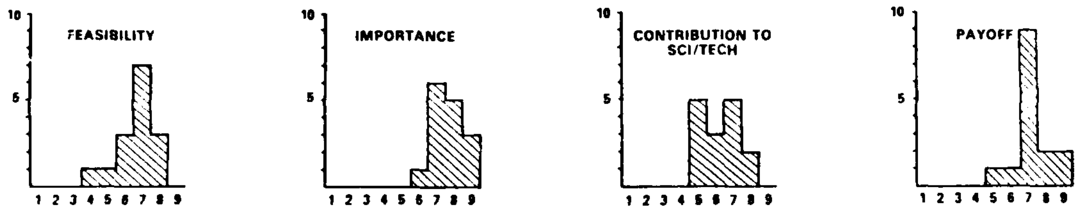
The "Manufacturing Scheduling and Resource Management Using I^2H" Project (Fig 3b) was originally classified as advanced development. It attempts to model an entire manufacturing capability to provide a communication data base with linkages to product/process definition, production, distribution, etc. Comments indicated doubt in the ability to model an entire manufacturing capability in three years, doubt as to the existence of a generic manufacturing process, and concern over underestimating the resource requirements. In addition, it was thought that it should be moved to exploratory development as existing approaches are better in the near-term. In the rewrite, the management of global resources was changed to available resources, and the classification was changed to exploratory development.

The "Design and Implementation of a Decision Support System for Manufacturing Management" Project (Fig 3c) was classified as exploratory development. It attempts to develop and implement a DSS that integrates already developed analytic tools to do planning and scheduling using ES technology. Comments indicated that the project would be factory specific or too broad (i.e., a collection of expert subsystems). The rewrite changed the milestones to include a requirements analysis which would specify expert systems for various decision scenarios.

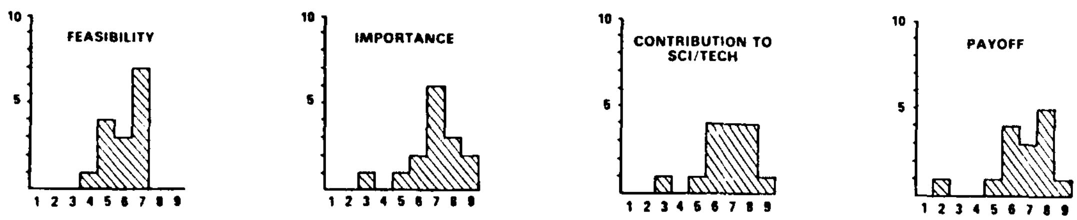
The project on ICONS for Manufacturing is an attempt to develop standard symbolic representations of manufacturing elements and by variation, depict the state of the manufacturing system. The results show the importance of various criteria in arriving at eventual project selection. The high feasibility is easily outweighed by problems that will be encountered in a standard development. Comments doubted the need for standard iconic representations and indicated that the project hits only a small portion of the important man-machine interface problem.

Table 4 I^2H Rankings

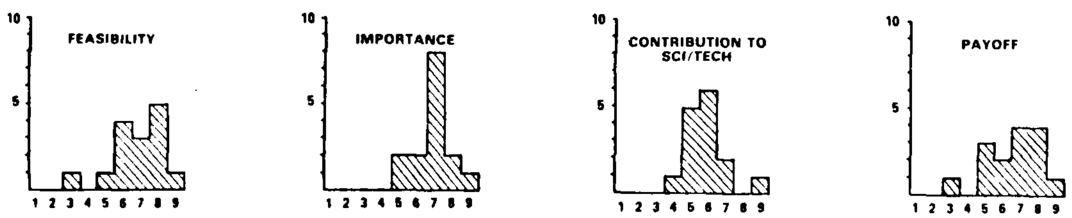
TITLE	FEASIBILITY	IMPORTANCE	CONTRIBUTION SCI/TECH	PAYOFF	RESULTANT
2nd Generation Data Base Machine	14	12	11	14	14
Manufacturing Scheduling and Resource Management Using Intelligent Information Handling	7	2	2	2	2
An AI Tool to Assist the Development of CIM Information Systems	6	5	5	5	6
An *Expert* System to Facilitate Design for Manufacturability	4	1	3	1	1
ICONS for Manufacturing Including Chernoff Variations	1	14	14	13	11
Group Technology Learning Mechanisms for Assembly	5	8	5	3	6
Intelligent Software Development Assistant	1[illegible]	11	13	11	13
Design and Implementation of a Data Model for Manufacturing	3	5	4	7	5
Standardized Knowledge Representation Scheme for Product/Component Functions	11	7	9	8	8
Process Prediction Processor	11	13	8	12	12
Design and Implementation of a Decision Support System for Manufacturing Management	2	4	7	3	3
Software Tools for System Scheduling	7	8	11	9	8
Expert Systems Specification and Design	10	10	9	10	10
Adaptive Data Base Systems for Computer-Integrated Manufacturing	7	2	1	6	3



3a An ES to Facilitate Design for Manufacturability



3b Manufacturing Scheduling and Resource Management Using I^2H



3c Design and Implementation of a DSS for Manufacturing Management

Figure 3 I^2H Frequency Distributions

This panel gives another example of the wealth of information contained in the data. Figure 4 shows the frequency distributions for a project considered by the I^2H Panel entitled "Intelligent Software Development Assistant". The ordinate and abscissa are the same as the previous figures.

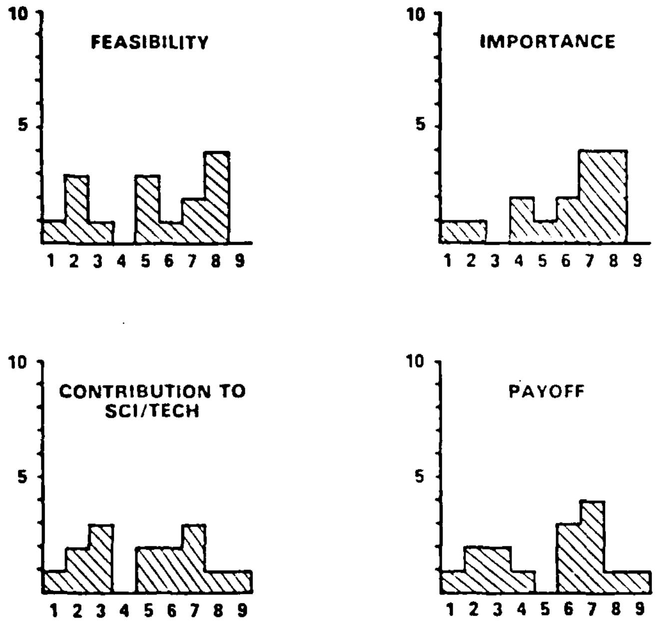


Figure 4 Frequency Distributions for Intelligent Software Development Assistant

An inspection of the figure shows substantial disagreement on all criteria. Some factors underlying this disagreement can be found from quotes taken from the reconciliation forms.

> "There is absolutely no content in this project description to work on this important problem."

> "I do not clearly see the need (most tools and their integration exists). Also, how can this be made computer independent?"

"Project hits an important need, but it is being addressed by other means in the industry. Hard to see that this project could produce a result that is broadly applicable. Severely underestimates the difficulty of developing software tools unless the project becomes very focused."

"Software development is too costly to be ignored in the realm of intelligent assistance. It touches every part of manufacturing and its size in manufacturing processes and systems will continue to grow. We must confine software's development costs."

Taking the numerical distribution and expert commentary together indicates that despite the lack of specificity of the project write-up, the area of intelligent software assistance is at least worth of further analysis.

At the end of the workshop phase, participants were asked to fill out a workshop feedback form. The form employed a seven-point Likert scale and also allowed for commentary. Table 5 shows the group means for the rating portion of the feedback. It is worthwhile to comment on information sufficiency (response 3 and 13) as it bears on results interpretation.

There were eleven participants who made comments concerning the lack of required specificity in the project write-ups. Comments indicated that the projects were, in some cases, vague, incomplete, insufficient to judge, lacked description for fair evaluation, and that they varied widely in quality. These appear to be valid comments. However, they are not "show stoppers". For example, the write-up for the manufacturing systems project on "Generative Process Planning for Manufacturing" was inadequate in that the importance to manufacturing words, as written, were nonresponsive and the resource estimate was extremely vague. Yet the participants were able to interpret and make value judgments. As a matter of fact, the project was ranked number 3 (out of 15) in terms of importance. If the goal had been to have work-ready projects, the specific wording of a project would be more critical. However, the experts were able to either interpret from as-written to as-intended or to use the reconciliation forms to highlight areas of concern.

The participants wanted more than the statistical information in order to reconcile differences. Ten participants commented on wanting more discussion time. This criticism is valid but care must be exercised in how improvements are implemented. It should be remembered that the purposes of the feedback were variance reduction and discussion generation on the important concepts. Free form discussion will evaporate. A project's score is important but the "why" behind the score is probably more important. While the concept of how best to reconcile differences is worth refinement, one cannot underestimate the need to "capture" as much expert information as possible. Thus, in the absence of taped sessions, the need to write down one's rationale is very important.

1	2	3	4	5	6	7
Very Small Extent			Neutral			Very Great Extent

Using the above scale, please respond to the following questions concerning the Workshop and the manner in which it was conducted.

To what extent.....

4.95 1. ...were you prepared for the workshop (e.g., did you read the projects prior to the workshop?)?

5.33 2. ...was preparation necessary or desirable?

3.18 3. ...did you find the information on the project description forms sufficient to make an assessment?

4.91 4. ...did the process facilitate or contribute to the attainment of the workshop objectives?

4.11 5. ...do you feel the criteria used for project assessment were adequate/comprehensive?

4.67 6. ...was the workshop process an effective use of your time?

5.67 7. ...did you have an opportunity to express your views/opinions?

4.98 8. ...were you personally satisfied with the results/outcomes of the group assessments?

3.93 9. ...do you feel your assessments are better overall evaluations of the projects than those determined by the group means?

2.93 10. ...did you feel forced to change your opinion to go along with the group?

4.11 11. ...were you satisfied with the process used in the workshop?

5.56 12. ...did you feel the members of your application area were sufficiently knowledgeable to provide accurate assessments?

3.55 13. ...did you receive enough information on the group assessments for reconciliation purposes (i.e., were means and standard deviations enough)?

4.79 14. ...do you feel the projects submitted were of sufficient quality to warrant this workshop?

5.15 15. ...do you feel you made a significant contribution to obtaining the objectives of the workshop?

6.50 16. ...would you like the results of the workshop made available?

Table 5 Group Means from Feedback Survey

The desire for more discussion time might also indicate a need for more immediate gratification of the usual workshop goals. That is, participants are usually an information sink at workshops, while the host organization is the source. In this case, these roles were reversed.

CLOSURE

The methodology employed in assessing AI needs in manufacturing involved concept definition, application area specific white papers that encapsulate the challenges of applying AI, project level detail, and statistical assessments of projects, coupled with expert commentary. The results indicate that particular attention needs to be paid to the trade between generic requirements (e.g., site independence) versus over generalization. A thrust relating to the idea of forging or closing the manufacturing to design link appears particularly worthwhile, with excellent projects in each of the application areas. Detailed analysis of the workshop data must consider the knowledge captured in comment form as well as numerical assessment. This project level information, coupled with goals, objectives, and concept constraints, provide a means for identification of research needs for AI in manufacturing.

APPENDIX A

UNIT PROCESS RESULTS

This appendix reflects the results from the deliberations of the Unit Process panel. It is organized as follows:

DESCRIPTION	PAGE
Sub-Panel White Paper	A-2
Panel Specific Criteria	A-5
Candidate Projects	A-7
Round 3 Assessment Statistics	A-39
Reconciliation Comments	A-43

WHITE PAPER

FOR

UNIT PROCESSES

DEFINITION

A unit process transforms material(s) or assembles parts by utilizing a combination of machine(s), tool(s), handling and inspection device(s), and human being(s). A unit process can be conceived as e.g. a machine tool performing a certain manufacturing process (lathe-turning) or a group of machines, handling devices, and human beings performing a particular manufacturing/service operation (cell). A unit process incorporates, as part of the manufacturing function, other operations such as inspection, maintenance, quality control, local resource allocation/planning, etc.

Three major areas of interest in unit processing are:

- o Design
  - This is closely related to the processes/function(s) that the unit is supposed to perform. One important aspect is interfacing/integrating the design phase of the product or part with the unit process.
  - Another aspect is the methodology/rules to be used to design the unit process itself.
- o Operation
  - An important aspect of this area is the degree of autonomy and intelligence which is to be integrated into the control system of the processing unit.
- o Interfacing with the manufacturing system.
  - This requires an intelligent means of collecting, processing and transmitting appropriate information/data.

MOTIVATION FOR RESEARCH

It has been posed that 60-80% of the cost of aerospace batch manufacturing costs reside in overhead. However, manufacturing experience would indicate that downtime and interruptions within the unit processes are substantial contributors to these overhead costs.

Cost reductions can be achieved by improving the utilization of manufacturing resources, e.g. machines, materials, human labor. Process level improvements can be accomplished by embedding sufficient intelligence at the unit process level to allow autonomous task planning in response to the goals and request of the manufacturing system. Additionally, the adaptability of the unit process to changing requirements and environmental status will reduce processing interruptions. Furthermore, by providing a bi-directional communication path between design and the unit process, better use of materials, labor and machines will be achieved.

An additional motivation is the desire to lessen the reliance on the skills of human operatives. AI will improve production consistency and allow for a continuous buildup of manufacturing skills and experience while eliminating recursive training of human operatives.

WHY AI?

AI has received a wave of publicity in recent years. With the decline of hardware costs and the availability of more sophisticated software tools, AI has emerged as a realistic technique that offers a very large variety of useful applications in unit processes in manufacturing practice. Some potential benefits are: (a) permanent and wider accessibility of human expertise, (b) a second opinion to that of a practicing expert, (c) the ability to handle uncertainty when data are incomplete, and (d) the ability to solve problems that have an extremely large set of possible solutions.

Due to the progress in e.g. knowledge representation, intelligent search techniques, and reasoning, AI is expected to make contributions in the following aspects of unit processes:

- computer-aided analysis, in terms of input preparation and result interpretation.
- process selection, in terms of resource utilization.
- process control, in terms of monitoring and adjustment of processing parameters due to disturbance.
- process understanding, in terms of timely feedback and reasoning of the current operation.
- user-system interface, in terms of intelligent display of the status of the process.
- flexibility and adaptability, in terms of quick process adjustments required by environment change.

However, the application of AI to unit processes is in its infancy. The elements of unit processes (transformation/assembly/service functions) have not been codified, nor has the knowledge base been organized. For example, for most unit processes the relationship of an operator's multi-sensory awareness to the decision rules to be invoked has not been established.

Because AI has not been widely applied to the unit process, the limits of the existing AI tools have not been established. However, it appears that knowledge acquisition at the unit process level represents a formidable challenge and may require additional concepts and tools.

GOALS/OBJECTIVES

In considering the potential benefits from applying AI to unit processes, we can list both broad goals and specific objectives. The former represent the long-term impact of AI on unit processes and the latter can be used as milestones to measure research progress.

The broad goals are:

- To improve the utilization of production resources.
- To improve the flexibility of unit processes.
- To improve the quality at the unit process level.

In addition, it is hoped that the application of AI to manufacturing will facilitate the discovery of new manufacturing technology and will inspire new AI techniques.

Some of the objectives in charting the progress toward the above goals are:

- Establishing adequate knowledge bases for unit processes.
- Develop and demonstrate sensor devices and strategies adequate for AI application.
- Develop inference engines and other AI tools proper for unit process control.
- Develop/apply AI techniques to improve the interaction between operators, designers, technicians, and automated manufacturing processes.
- Develop and demonstrate flexibility of a unit process to adapt to changes in local environmental status.
- Develop a system that maintains product quality despite changing process parameters.
- Improve the ability to furnish appropriate process information to the system level.
- Provide adaptive documentation/traceability information.

UNIT PROCESS PROJECT ASSESSMENT CRITERIA

USE THE FOLLOWING SCALE FOR CRITERIA 1 THROUGH 4

1	2	3	4	5	6	7	8	9
Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree

C1. CONSISTENCY WITH OVERALL GOALS/OBJECTIVES. The goal of the proposed project is in keeping with the overall objectives of the program. For example, does the proposed project represent an innovative AI application to unit processing, will it improve a unit process and will it contribute to the knowledge base of manufacturing and AI applications?

C2. IMPACT. The project makes significant contributions to: the technology base, the manufacturing community, and education in terms of the following attributes:

1. Breadth of impact, e.g., number of companies/institutions affected.
2. Depth of impact, e.g., number of processes affected.
3. Potential spinoffs.

C3. PAYOFF. The project provides a substantial payoff in terms of either financial benefit or mission capabilities or both. Financial benefit follows standard return on investment and cost reduction criteria for specific projects, technologies or classes of manufacturing firms. Mission capabilities are represented in the ability to produce high outputs during mobilization and high production quality and reliability as well as flexibility in set-up for new products or expanded processes.

C4. TECHNICAL FEASIBILITY. The proposed project is feasible in terms of achieving its objectives and demonstrating soundness of approach.

USE THE FOLLOWING SCALE FOR CRITERION 5

1	2	3	4	5	6	7	8	9
Very Low		Low		Agree		High		Very High

C5. ESTIMATE REALISM. The project proposal reflects a realistic estimate of the required resources (in dollar and person-years) and the expected elapsed time.

FOR WORKSHOP USE
CODE # I

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES ____ MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: AI Configuration Design of Modular Fixturing Based on System Dynamics

PROBLEM DEFINITION/PROJECT OBJECTIVE: The project objective is to develop and demonstrate feasibility of a rule-based system which configures modular fixturing for a unit process and learns to revise its rules based on actual achieved performance. The design of modular fixturing configurations are currently limited by the experience of the shop floor and engineering support in minimizing dynamic process problem due to fixturing. The dynamic properties of fixture modules are not well organized as a knowledge base, and the interconnection problems are handled ad hoc, based on shop floor experience.

PROJECT DESCRIPTION/APPROACH: The theoretical work will be bounded by addressing only one type of unit process, i.e. milling. Similarly, the experimental work will address one part family. The technical analytic problem of dynamic modeling will be handled by FEM substructuring modal analysis methodologies. This analytic portion will configure the fixturing models (including the part) and will estimate system dynamics. The AI system will reconfigure the system to minimize dynamic interaction with the process (chatter). Experimentally determined structural properties will be used to modify the rule based on upgraded knowledge of the module interface efforts.

IMPORTANCE TO MANUFACTURING: The selection and evaluation of fixtures is one of the major limiting factors in present unit processes for machining. In general, this factor causes most machining systems to be limited to problems for which proven fixtures exist. Thus, manufacturing flexibility is severely limited. In order to prove a new fixture, a combination of analytic knowledge and shop floor experience is used. Thus, the proposed AI approach promises to improve the productivity of small batch unit process milling operations. Its impact will be felt across all types of manufacturing organizations and will be a significant addition to the technology base required for truly flexible machining cells.

FOR WORKSHOP USE
CODE # 1

CONTINUATION OF (project title) AI Configuration Design of Modular Fixturing Based on System Dynamics.

POTENTIAL PAYOFF (quantitative, if possible): The proposed project has the potential to reduce substantially the trial and error methodologies used in fixturing development. In addition, it will promote a truly flexible fixture design which will substantially reduce the number of specialized fixtures which are currently maintained in inventory. The labor offset, setup, reduced engineering requirements, and reduced inventory cost should provide a very attractive ROI for batch manufacturing.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The structural analysis technologies are well developed for geometries with few joints. Expert knowledge is still required to handle the joint (and part-gripping) interface. Because modular fixtures involve multiple joints, experience must be accrued for fixture configuration change. This joint/interface problem represents a new knowledge base which will be broad implication for machine design in general.

PROJECT DURATION: 4 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

Design of modular fixture blocks
Development of substructured dynamic models and their experimental verifications } yr. 1
Development of combination scheme and rules for configuration
Demonstration of initial expert system } yr. 2
Development of learning rules based on experimental data yr. 3
Demonstration of AI learning in fixture configuration yr. 4

RESOURCE REQUIREMENTS:

	Faculty	Grad Student	Software	Hardware
Year One	1	2	$10,000	$20,000 (Fixture Mfg.)
Year Two	1½	2	$20,000	$ 5,000
Year Three	2	2	$20,000	$ 5,000
Year Four	2	2	$20,000	$ 5,000

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)
___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 2

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: A Grasping Expert for an Automated Machining Cell

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective is to provide robots with the ability to decide how to pick up simple parts in order to fulfill assembly and fixture-loading tasks. In addition, the grasping expert will permit the robot to re-grasp or modify an initial grasp in response to changing task descriptions.

PROJECT DESCRIPTION/APPROACH: The project will focus on two basic part styles (with individual variation within a style). A simple gripper (e.g. parallel-jaw) will pick up the parts for assembly or for loading into one of several different fixturing configurations. The rule based system will build upon existing solid-modeling capabilities & will use an existing manipulator language for motion description and output to the robot. It will be assumed part orientation, gripper dimensions, and fixturing dimensions are approximately known.

IMPORTANCE TO MANUFACTURING: Today's robots are tedious and time-consuming to program for each new part style. Whether the programming is done manually (by teaching) or off-line using a CAD description, the effort involved contributes substantially to the expense of re-tooling for a new part style. A robot with the ability to decide how to grasp parts would be much easier to program. It would also be more tolerant of variations in part presentation. Finally, this work paves the way for robots that can work in less structured environments, including maintenance applications.

FOR WORKSHOP USE
CODE # 2

CONTINUATION OF (project title) A Grasping Expert for an Automated Maching Cell

POTENTIAL PAYOFF (quantitative, if possible): A robot with the ability to grasp would cut robot programming significantly. This is a first step toward robots that require no manual teaching. In many cells, robot programming currently requires 10+ man hours per part change. An additional benefit is the reduction of interruption and errors due to the inability of today's robots to cope with errors in part presentation.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The grasping expert will extend the current understanding of grasping and manipulation. It is an important first step toward a more general intelligence for parts handling. The expert will also build upon existing kinematic theories, robot programming languages, and solid modeling techniques.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

1 yr. - basic formulation of grasping rules.
develop interface with robot programming language & solid modeling.

2 yr. - demonstrate application with fixture loading.

3 yr. - extend rule base to allow for regrasping based on changes in task description or reported error conditions. Demonstrate with basic part styles.

RESOURCE REQUIREMENTS:

Robot Solid Modeling & Robot Programming Language

Graphics Workstation (eg.SUN)

Labor: Estimate 3 Person years/year

PROJECT CLASSIFICATION (please check one):

X Basic Research (long-term) ___ Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE #

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Knowledge Base System for Computer-Aided Analysis Packages for Unit Processing.

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of this project is to develop an intelligent knowledge base system in assisting unit process designers to select/apply existing computer-aided analysis packages. The knowledge base developed will serve as a repository for all computer-aided analysis packages (including existing, under development, future development) for use by the unit process designers. The knowledge base system developed will assist unit process designers to select the appropriate package to apply, based on their needs.

PROJECT DESCRIPTION/APPROACH: The project will apply AI in representing and structuring the knowledge embedded in the computer-aided packages. The project will also apply AI techniques to guide the unit process designers to select appropriate package(s). The project will proceed with the: 1) compilation of knowledge, i.e., the methodology, and the requirement, and possible application areas of the computer-aided analysis packages; 2) development of a knowledge representation paradigm for structuring and representing the knowledge compiled and synthesized in 1); 3) development of an intelligent knowledge base system in assisting unit processor to select/apply the packages. The knowledge base system will also provide ways to allow package developers to add/modify/upgrade the knowledge base.

IMPORTANCE TO MANUFACTURING: The development is very important, considering the number of computer-aided analysis packages developed for unit process design over the years, yet many packages are not being used due to the lack of the knowledge of the existing packages. By providing an intelligent system to the unit process designers, appropriate packages can be selected and applied, which in turn, will: 1) reduce or even eliminate redundant efforts in developing similar packages; 2) produce better products/parts in a more efficient way through the use of the packages; 3) reduce amount of training/learning required to apply these packages properly.

FOR WORKSHOP USE
CODE # 3

CONTINUATION OF (project title) Intelligent Knowledge Base System for Computer-Aided Analysis Packages for Unit Processing.

POTENTIAL PAYOFF (quantitative, if possible): The potential payoff is significant, & is derived from better use of R&D expenditures by the government and industries. With the develoment of this system,existing unit process design packages can be more widely and intelligently used.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Since the knowledge base will serve as a repository for all computer-aided analysis pacakges for unit processes, the contributions of thisproject are significant. In addition, this knowledge base can be used to educate the unit process designers in applying state-of-the-art technology with little effort.

PROJECT DURATION: 2 CALENDAR YEARS

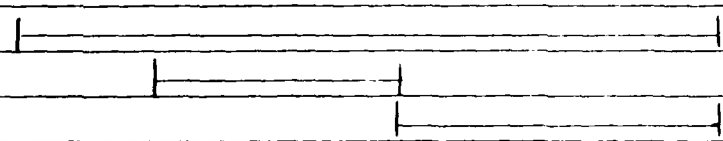
MAJOR MILESTONES (include timeframe):

Start 6 month 12 month 18 month 24 month

knowledge compilation

knwoledge representation paradigm

knowledge base system development



RESOURCE REQUIREMENTS: Person years required: 5 (knowledge compilation = 2
knowledge representation = 1
knowledge base system = 2)

Hardware required: VAX Super Mini class computer (e.g. VAX 11/750)

Software required: FORTRAN, AI language (Common LISP)
Knowledge Engineering tool (e.g. ART by Inference Corp.)

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 4

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES ____ MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Rule Based System For Intelligent Integration of Multiple Sensors In Assembly Tasks

PROBLEM DEFINITION/PROJECT OBJECTIVE: In assembly of irregular components, the use of several types of sensory information is required for mating, insertion, interlocking, and other classes of assembly tasks. As yet, a methodology has not been developed which would allow for the selection and appropriate utilization of sensory data in an adaptable, dynamic environment to address these tasks. A generic rule based system will be developed for a bounded set of parts, tasks, and sensors which could then be further expanded for additive complexity.

PROJECT DESCRIPTION/APPROACH: This project would utilize tactile sensing in a robot gripper and machine vision to assemble an irregular parts class of electronic cable connectors and recepticle mating. The assembly task would be analyzed to determine the knowledge base and inference rules required and to reduce the complex task into discrete generic sub-problems. The vision and tactile sensor data outputs would be classified orthogonally, according to their appropriate utilization in these sub-problem in the form of an interaction matrix. A prototype system would be constructed to demonstrate the resulting intelligent assembly of various connector types.

IMPORTANCE TO MANUFACTURING: Cable interconnection of electronics units is an area of assembly that has not been automated. With increasing use of electronic components in manufactured items,this task is expected to grow in the forseeable future. Automation of this task will establish a generic rule based methodology for adaptive assembly of irregular parts. The system can be extended to include additional sensors, parts classes, and assembly tasks to provide flexibility in unit processing. These tasks are pervasive throughout manufacturing and will advance the state-of-the-art in automated assembly technology.

FOR WORKSHOP USE
CODE # 4

CONTINUATION OF (project title) Rule Based System for Intelligent Integration of Multiple Sensors in Assembly Tasks

POTENTIAL PAYOFF (quantitative, if possible): Payoff from this task is achieved both financially and in mission capabilities. Assembly of irregular items is a labor intensive activity that has not been successfully automated. The flexibility of an automated system to adaptively join items such as cable connectors has relevence in field tactical tasks as well as in the manufacturing context. Communication with the unit processes during assembly would also assist scheduling and planning in assembly and inspection of finished products. A minimum of 25% ROI is anticipated through labor red. & qual. impr.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This project would be the first attempt to develop a generic rule based system for the integration of multiple sensors in this class of manipulative tasks. The fundamentals established would form a foundation for advancing the state-of-the-art in automation assembly.

PROJECT DURATION: 2.5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): I Determination of appropriate parts boundaries and selection of sensors - 1 month

II Analysis of assembly task sub-problems and sensory data application - 5 months

III Structuring & formulation of knwoledge bases and inference rules - 6 months

IV System component selection, procurement, and interconnection - 6 months } simultaneous

V AI coding and component interfacing - 6 months }

VI System testing and demonstrations - 6 months

RESOURCE REQUIREMENTS: This project would require 5 to 8 professional man years to demonstrate the laboratory proof-of-concept system. A personal service budget of approximately $800,000 plus equipment (specialized) and travel as required is anticipated.

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term)   X Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 5

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Processing of Composite Materials

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective is to develop and demonstrate the use of combined numerical models and knowledge based decision making for optimizing and controlling the curing of composites. The emphasis will be on the thermal balance during the curing process.

PROJECT DESCRIPTION/APPROACH: At the present time one-dimensional heat transfer models are available for describing the composite curing process; void and internal stress models are not available. Extensive experience for processing composites relative to void and stress growth is available. The goal will be to combine the thermal models with the void/stress experience in a computer.

IMPORTANCE TO MANUFACTURING: At the present time, the control conditions for curing composites are predetermined; after curing, the composite material quality is determined. The proposed approach exploits both the heat transfer models as well as the materials engineer's void/stress experience for on-line control of the curing process. Manufacturing applications should be improved because of both heat transfer and void/stress input on-line.

FOR WORKSHOP USE
CODE # 5

CONTINUATION OF (project title) Intelligent Processing of Composite Materials

POTENTIAL PAYOFF (quantitative, if possible): The payoff includes fewer rejected parts due to improved quality for existing materials. More importantly, new superior materials have a smaller processing window (more sensitive to initial conditions - history of the precured material); these new materials have not been used extensively in manufacturing due to the cure cycle/quality control complexity.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The proposed project includes combining models and knowledge base data in a control environment.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

1.5 year: knowledge base program

2.0 year: combined model/knowledge base program

3.0 year: operational and verified program

RESOURCE REQUIREMENTS: 1 knowledge-base programmer/engineer for 3 years

1 modeler/engineer for 1 year

1 control engineer for 1 year

5 manyears total

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 6

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES ___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Adaptive Planning for Automated Fab/Assembly Operations

PROBLEM DEFINITION/PROJECT OBJECTIVE: Current automated flexible work cell concepts implicity assume man-in-the-loop operation, with computer control exercised through off-line programming. Fabrication and assembly operations in robotic work cells, to the extent that they exist, are programmed in detail for each operation and each part or sub-assembly. This requires on-going programming support for engineering changes as well as human intervention for unanticipated events during processing. The objective of this project is to develop an intelligent planning system capable of automatic process modification and contingency resolution, thus permitting true stand-alone cell operation.

PROJECT DESCRIPTION/APPROACH: The proposed planning scheme requires a CAD/CAM interface and a knowledge base in the form of a "how to" experiential data base representing the expert cell operator. The initial fab/assembly plan is automatically generated by backward dissolution from the CAD/CAM representation. The plan is then interactively executed with sensory feedback. Sensor information is used to verify pre and post conditions for each step in the plan. When these conditions are not met, an alternate plan is formulated and executed to restore the require conditions.

The proposed planner would be essentially a real-time executive controller for several of the other proposed intelligent modules, including expert grasping, rule based sensor integration, and modular fixturing. It would interface with those modules dealing with engineering change management, generative process planning, and shop scheduling.

FOR WORKSHOP USE
CODE # 6

CONTINUATION OF (project title) ______________________

POTENTIAL PAYOFF (quantitative, if possible): A fully developed stand-alone work cell operating at full capacity eliminates at minimum a four man level of effort in DOC and a maximum of eight man level of effort in total cost. The minimum is simple man replacement. The maximum estimate includes savings due to decreased programming support, increased throughput, improved quality, and decreased manufacturing, engineering, and administrative support.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The research and development proposed for this project will make important contributions in the understanding and implementation of knowledge bases and the representation of human experience. The technology to be developed under this project is a necessary precursor to the implementation of a fully automated factory, because it integrates and directs many other segments of automation.

PROJECT DURATION: 4 **CALENDAR YEARS**

MAJOR MILESTONES (include timeframe): (1) Define a representative automated flexible fabrication or subassembly cell. Perform a detailed functional decomposition of the cell and concurrently develop experiential data base (2 years). (2) Concurrently develop the dynamic planner in hierarchial form, providing scars and hooks for intelligent sub-systems as well as factory level super-systems (2 years). (3) Perform brassboard demonstration of the system, interfacing with state-of-the-art CAD/CAM, sensory, and robotic hardware and software (2 years).

RESOURCE REQUIREMENTS: 1 Principal Researcher, 2 Senior Researchers, and 5 graduate students for 4 years. Existing robot and automation lab will be used. A new dedicated AI computer and interfacing will be required, cost approximately $100,000.

PROJECT CLASSIFICATION (please check one):

___ **Basic Research (long-term)** _X_ **Exploratory Development (mid-term)**

___ **Manufacturing Technology or Advanced Development (near-term)**

FOR WORKSHOP USE
CODE # 7

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

XX UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: A TEACHABLE UNIT PROCESS

PROBLEM DEFINITION/PROJECT OBJECTIVE: Expert systems are essentially a high-level programming language and acquisition of their domain-dependent knowledge base is the main constraint in their implementation. This project would develop an interactive system that, during a teaching period, builds on previous knowledge, generating the required domain-dependent program and knowledge base.

PROJECT DESCRIPTION/APPROACH: Although the teachability concept can be applied at any level in the Unit Process, a testbed of an assembly operation using a manipulator, force/torque, tactile, and visual sensor would be used. A complete set of primitive operations for each element in the testbed would be defined and implemented as a basis for future teaching. An assembly program would be generated from the primitive operations (both manipulations and sensory feedback), previous plans, and operation instruction. Teaching would consist of an operator monitoring task execution, examining the sessions for an action, altering the actions when desired, and inputting detailed instructions when the system does not know how to proceed.

IMPORTANCE TO MANUFACTURING: Expert systems are extremely difficult to implement, requiring a programmer to understand both the shop floor operations and the complex rule-based programming structures (a rare combination). Using a teachable system would remove the programmer and allow a shop person to teach the system in a manner similar to training a new employee. This teaching system would supercede expert system approaches allowing AI to be incorporated into manufacturing processes in a cost- and time-effective manner.

FOR WORKSHOP USE
CODE # 7

CONTINUATION OF (project title) A TEACHABLE UNIT PROCESS

POTENTIAL PAYOFF (quantitative, if possible): This approach, though applied at the manipulator level, could be used at any level, providing significant cost and time savings. Acquiring an expert system knowledge base is extremely difficult and could potentially stifle integration of AI into manufacturing processes. The teaching approach provides an alternative.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The intelligence of a system is a quality but can be quantified on a scale of knowledgable, communicative, teachable, able to learn, and able to create. This system would extend the state of the art from expert systems that are knowledgable and communicative to systems that are teachable, and pave the way for systems that can learn without instruction.

PROJECT DURATION: 4.0 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

I	(Assuming the manipulator/sensor testbed exists) Creation and coding of the primitive operations	0.5 yr
II	Development of a limited natural language interface	0.75 yr
III	Development of an inference engine to generate alternative actions at any point in time, recording the new plan in memory	1.25 yr
IV	Development of a control structure to interface the testbed, inference engine, & operator	1.0 yr
V	System testing, demonstation, documentation	0.9 yr

RESOURCE REQUIREMENTS:

Approximately a 20 man-year effort.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 8

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES ___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: AI Technology for Real Time Machine Control

PROBLEM DEFINITION/PROJECT OBJECTIVE: The application of AI tools and concepts to unit processing equipment holds great promise for improving utilization, flexibility, and quality. However, current AI technology was largely developed in a "mainframe" computer environment and concept formulation was emphasized over speed. The objective for this project is to determine requirements and practical approaches for using AI hardware and software for real time machine control.

PROJECT DESCRIPTION/APPROACH: The project will consist of three tasks: a) Marriage and evaluation of an AI workstation and a machine (robot, machine tool, etc.) demonstrating real time control; b) Development of relevant software techniques including: 1. decision making under time constraints, 2. management of time uncertainties from dynamic memory, 3. flexible sensor monitoring strategies. c) A vendor program to determine and communicate/advocate realistic requirements (packaging, performance, price) to AI technology supplies.

IMPORTANCE TO MANUFACTURING: The results of this project are essential for the practical implementation of AI-based approaches to improving unit processes. This work will enable advances in unit processing in a broad range of industries.

FOR WORKSHOP USE
CODE # 8

CONTINUATION OF (project title)

POTENTIAL PAYOFF (quantitative, if possible): The value of this project is to allow the capture of economic benefits from general AI research advances at the unit processing level. The knowledge, tools, and computer systems produced will enable manufacturers to implement these ideas and realize tangible gains.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Research in this area will advance scientific knowledge in temporal reasoning, planning and decision making under time constraints, and sensing strategies. In addition, the availability of an AI workstation interface for a machine (particularly a robot) will significantly enhance university-level education. One major hurdle in graduate programs today is the lack of modern factory equipment with an accessible, lower level software interface for research.

PROJECT DURATION: 4 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): I. Analyze existing AI workstations and determine strategy, 1/2 year; II. Demonstrate running prototype, 2 years; III. Complete prototype field evaluation, 1 year; IV. Produce research support package, 1/2 year; V. Initial vendor requirements, end of year 1; VI. Final vendor requirements, end of year 2.

RESOURCE REQUIREMENTS: Manpower: 16 man years
Hardware: 2 AI workstations
2 unit processing machines
Software: 2 knowledge representation language packages
(e.g., KEE, ART, CRL)

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) XX Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 9

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

x UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Knowledge Based System to provide format compatibility for dissimilar NC machine control combinations

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of this project is to develop an intelligent knowledge based system to permit proper execution of NC programs for dissimilar NC machine control combinations. The result of the project will permit more flexible scheduling of manufacturing facilities.

PROJECT DESCRIPTION/APPROACH: Many requirements for tape compatibility are avoided because of undocumented features. These features require significant engineering when encountered in a product already designed. The project will apply a rule based design approach to permit easy initial design and allow accommodation to the unexpected and undocumented requirements. The major steps are: 1) Determine the tape format and critical postprocessor functions of 10 of the most commonly used machines; 2) Develop a Rule Based System to provide NC data conversion between these formats; and 3) Field test to verify interchangeability.

IMPORTANCE TO MANUFACTURING: Whenever an NC tape data set is produced, it is bound to a particular machine/control combination. Because of this early binding, constraints are placed on the operation of the manufacturing facility. Machines with physical capacity to process a given part are excluded from selection because they cannot assimilate the NC data stream of the selected machine. The BCL format is one attempt to provide the standardization of input that would allow interchangeability of input data; however, there exists a large number of existing machines installed in the field and a number of new machines not yet capable of reading the BCL data. The development of a tape interchangeability device would provide many of the benefits of BCL without awaiting the broad based installation of that technology.

FOR WORKSHOP USE
CODE # 9

CONTINUATION OF (project title) Intelligent Knowledge Based System to provide format compatibility for dissimilar NC machine control combinations

POTENTIAL PAYOFF (quantitative, if possible): The result of this project would allow parts to be machined on any machine with the range, horsepower, and accuracy to meet the part requirements regardless of the manufacturer. This will make possible increased flexibility and competition in the development of subcontracts. Furthermore, the operation of individual machining facilities will be enhanced by the increased flexibility available to the shop management.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This would be an implementation of an embedded rule based system. It would also prove the value of rule based systems in the development of systems wherein the design parameters are incompletely documented.

PROJECT DURATION: 1.25 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Select the machine/control combinations. Determine the conversion parameters. Develop the conversion software. Verify the performance.

RESOURCE REQUIREMENTS:

1.	Select the machine/control combinations		.1 MY
2.	Determine the conversion specs		.25 MY
3.	Develop the conversion software		.5 MY
	Personnel Computer	$7000	
	Rule Based Language	$3000	

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) ____ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

(CONTINUED RESOURCE REQUIREMENTS)

4. Verify the performance at 1 site 3 units .5 MY
   Additional computers and software $30,000

FOR WORKSHOP USE
CODE # 10

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES ___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Expert System for the Design of Castings

PROBLEM DEFINITION/PROJECT OBJECTIVE: As is the case with all manufacturing processes, the geometry of a machined part, ready for assembly, must be modified to make the part "producible" via the manufacturing process under consideration. In case of castings, certain part dimensions may be increased, radii at junction of ribs may be modified and so on. These design modifications are not algorithmic and are made using experience based design rules. Thus, a rule based Expert System would be extremely helpful to the designer, would reduce training time and help to maintain expertise recorded systematically.

PROJECT DESCRIPTION/APPROACH: Two steps are involved. The first consists of gathering casting design rules (based on casting type and material). These rules define the minimum wall thicknesses, corner and fillet radii, draft angles, if any, and all other geometrical features of a casting. The second is the development of the Expert System that will use these rules. This system must be interfaced with a commercially available geometric modeling CAD/CAM system such as UNIGRAPHICS or ANVIL. Thus, the geometric description capabilities do not have to be redeveloped. Work could be done initially on 2-D sections of a casting. Based on progress, the system would be expanded to handle 3-D geometries.

IMPORTANCE TO MANUFACTURING: Several aspects are important:

1. The use of AI/Expert Systems techniques to design for producibility can be applied to nearly all processes casting, forging, injection molding, extrusion of shapes, etc. Thus, a modern design technique would be created as an example.
2. The system would (a) save design time and increase designer productivity, (b) allow the storage of valuable experience, (c) facilitate the training of younger engineers, and (d) can be improved continuously by modifying the design rules.

FOR WORKSHOP USE
CODE # 10

CONTINUATION OF (project title) Expert System for the Design of Castings

POTENTIAL PAYOFF (quantitative, if possible): Difficult to quantify, but will

a) reduce lead times and design cost
b) increase design quality and reduce manufacturing problems due to faulty design, and
c) provide an excellent interface between design and manufacture, which improves the entire production cycle.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

1. Systematic Storage of Design Rules for Castings
2. Identification of areas that need R&D to improve casting shape complexity and reduce scrap.
3. Development of a relatively objective methodology for design for producibility that can be applied to nearly all manufacturing processes.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

1st Year a) Gathering of design rules, extensive communication with casting companies and b) Selection of appropriate AI tools for system development.

2nd Year a) Develop a Prototype System, b) continue to gather rules, c) start Expert System development.

3rd Year a) complete writing of Expert System, b) test in cooperation with casting companies.

RESOURCE REQUIREMENTS:

1st Year 1.00 Man Years
2nd Year 1.25 M.Y.
3rd Year 1.25 M.Y.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 11

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Machine Monitoring Expert System

PROBLEM DEFINITION/PROJECT OBJECTIVE: This Machine Monitoring Expert System will provide monitoring of manufacturing equipment to detect changes in operational status that indicate maintenance and repair are needed.

PROJECT DESCRIPTION/APPROACH: Impending bearing failures have been detected in rotating machinery from changes in the frequency response spectrum of accelerometers used as detectors. This system would combine the AI techniques of expert systems with the machine monitoring technologies. The system would detect imminent failures, diagnose them and suggest corrective action.

IMPORTANCE TO MANUFACTURING: This system would improve maintenance and thus reduce the overhead or non-touch labor in manufacturing. By monitoring the operational status on a short periodic basis and detecting imminent failure the problem can be corrected on a non-critical time. This avoids the cost of a machine that breaks down in the middle of a production run.

FOR WORKSHOP USE
CODE # 11

CONTINUATION OF (project title) Machine Monitoring Expert System

POTENTIAL PAYOFF (quantitative, if possible): Reduction of maintenance costs, reduction of down time during production and thus higher productivity from the manufacturing facility.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Application of AI to maintenance management. Capturing the knowledge of maintenance experts in a knowledge base.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): First year - build knowledge base; Second year - build a prototype system for rotating machinery; Third year - build a generic system to allow for a wide variety of machines, sensors, and detection data for general application.

RESOURCE REQUIREMENTS: 5 man years

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) ____ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

CODE # 12

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES ___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Assembly Planning for Intelligent Robots -

PROBLEM DEFINITION/PROJECT OBJECTIVE: The goal of the proposed project is to develop a planning system that would be suitable for automatic assembly of parts by a robot in a manufacturing environment. It is assumed that the robot is equipped with visual, tactile and force sensors and a dextrous hand for manipulation. The planner will rely on the sensors for environmental information that may be required for planning purposes. The planner would interleave planning and execution, monitoring execution of the plan/partial plan with the aid of the sensors and replan where necessary.

PROJECT DESCRIPTION/APPROACH: The planning problem in AI has received considerable attention thus far. The problems of representation and inferencing that occur in any problem-solving system as well as problems that are specific to planning such as sub-goal interactions have been examined. There is currently some work in progress to deal with the explicit representation and reasoning of time. The robotics domain poses the additional problems of incomplete information and unexpected changes in the environment. Our approach then is to build on the existing planning technology and use the availability of the sensors to cope with the dynamic nature of the environment. The focus of our work will thus be on integrating sensory information into the planning and execution monitoring processes.

IMPORTANCE TO MANUFACTURING: We believe that developing a dynamic planner as described above would specifically contribute to the operational aspects of unit processes by increasing the degree of autonomy of the processing unit. It would serve to increase the reliability of the processing unit by making it more adaptable to changing requirements and environmental status. The work aims to improve to improve process understanding by integrating sensors for providing feedback and reasoning about assembly operations.

FOR WORKSHOP USE
CODE # 12

CONTINUATION OF (project title) Assembly Planning for Intelligent Robots

POTENTIAL PAYOFF (quantitative, if possible): The specific advantages of this work would be in realizing a reduction in downtime and interruptions arising in unit processes. The work is exploratory in nature and when completed, it would help evaluate the cost/benefit of including more knowledge and reasoning capabilities into unit processes.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The work attempts to model and integrate the notions of perception, action and reasoning in a realistic and complex domain and thus addresses a challenging and relevant problem in the field of AI.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): 1.

1. Development of a static planner for the assembly domain, focusing on the acquisition and organization of knowledge relating to assembly process and relying largely on existing planning technology for issues of representation and control. (6 months). 2. Extending the planner developed in the previous phase into a dynamic planner with simulated sensory information and manipulator actions and developing satisfactory approaches, modifying representation and control mechanisms as necessary, for integrating the sensory information into the planning process, dealing with execution monitoring, and replanning. (18 months). 3. The last phase of this work will be the integration of the dynamic planner developed with actual sensors and dextrous hand and the study of real-time issues involved in the planning approach developed in the previous two phases. (12 months).

RESOURCE REQUIREMENTS: Currently the static planner is being developed on a Symbolics 3600 LISP Machine. Exploratory work in Phase 2 and all work in Phase 3 require use of a computer network (with systems for planning, vision and touch processing, and distributed motor control), sensors, and a robot equipped with (at least one) dextrous hand.

Budget: Planning Work $ 100,000 annually; Related development of sensors and robot control system, $ 150,000 annually.

PROJECT CLASSIFICATION (please check one):

X Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 13

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

X UNIT PROCESSES

___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Distributed Intelligence Among Unit Processes

PROBLEM DEFINITION/PROJECT OBJECTIVE: In an uncertain environment, intermediate and long-range planning are often futile. It is better to make decisions as the need arises rather than in advance. The aim of this project is to develop the AI tools needed to make such decisions at the unit process level.

PROJECT DESCRIPTION/APPROACH: Decisions regarding part flow, resource usage, and component supply can be made in a distributed or non-hierarchical manner. These decisions are made at the unit process level.

This approach requires an effective communication system, or "data highway", between processes. It further requires that the unit process themselves exhibit considerable intelligence. AI methods seem an appropriate vehicle to express that intelligence.

IMPORTANCE TO MANUFACTURING: Distributed intelligence would improve throughout and provide the benefits associated with that. The improvement should be particularly noticeable in situations with a great deal of uncertainty.

FOR WORKSHOP USE
CODE # 13

CONTINUATION OF (project title) ______

POTENTIAL PAYOFF (quantitative, if possible): ______

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Improvements in development of artificial intelligence methods; improvements in inter-process communication.

PROJECT DURATION: 4 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): ______

RESOURCE REQUIREMENTS: 20 MY

PROJECT CLASSIFICATION (please check one):

- ___ Basic Research (long-term)
- X Exploratory Development (mid-term)
- ___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 14

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

x UNIT PROCESSES ____ MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Rule-Based Process Diagnosis

PROBLEM DEFINITION/PROJECT OBJECTIVE: The quality control problem in a manufacturing system can be decomposed into three subproblems: recognizing a change in system behavior (inspection); explaining the behavioral change in terms of changes to the system structure (diagnosis); and recovering from the changes in the system structure (adaptive control). The objective of the project is to develop a feasibility demonstration diagnosis system that will generate explanations of observed part quality problems in terms of defects in the unit processes that produced the part. Thus, it will serve as a bridge between the part inspection and process control functions of a manufacturing system.

PROJECT DESCRIPTION/APPROACH: A rule base will be developed to model the causal relations of unit processes and parts. The model will relate symptoms (inspection data) to process states, and relate process states to physical defects in the process. An inference engine will be developed to explain part defects in terms of defects in one or more processes involved in manufacturing the part. The project effort will include designing the rule base structure, generating the rule base by interviewing experts, defining the structure of the input data and the results of the diagnosis, implementing an inference engine, and test and demonstration of the system. As a feasibility demonstration, the project will be limited to the diagnosis of simple milling and lathe operations.

IMPORTANCE TO MANUFACTURING: The usual way of dealing with quality problems is to assemble a material review board (MRB) to diagnose the problem. The MRB function is critical to the future health of a system; without accurate results, the system will continue to create bad parts. The MRB function is also one of the most difficult functions to automate; it usually requires the interaction of several experts. A rule-based diagnosis system will provide a structure that can incrementally capture the required expertise and lead to an automated, reliable, and robust link between inspection and control.

FOR WORKSHOP USE
CODE # 14

CONTINUATION OF (project title) Rule-Based Process Diagnosis

POTENTIAL PAYOFF (quantitative, if possible): This project will achieve several goals. It will demonstrate feasibility of an AI approach to MRB functions. It will help define the role of part inspection in an automated manufacturing system. And it will contribute to defining data standards between inspection and control functions.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The major issue in applying rule-based diagnostics to manufacturing is that the processes involved in making a part interact. One process may remove evidence that another process was out of control. Also, several processes may contribute errors. Finally, an error may not be attributable to one process exclusively, but to the interaction between processes. These interactions require new inference mechanisms capable of diagnosing multiple faults.

PROJECT DURATION: 2.5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (times given are from start of project)

1) Design rule base structure: 6 months
2) Develop rule base; 8 months
3) Generate test data; 9 months
4) Implement inference engine for multiple-fault reasoning; 24 months
5) Build prototype system; 28 months
6) Feasibility demonstration; 30 months

RESOURCE REQUIREMENTS: 8.5 staff-years, $765K; AI Computer System, $30K.

PROJECT CLASSIFICATION (please check one):

XX Basic Research (long-term) ____ Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 15

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

X UNIT PROCESSES ___ MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: AI for Process Design and Control Using High Speed Medium - to Large-Grain Parallel Computers

PROBLEM DEFINITION/PROJECT OBJECTIVE: A large disparity in knowledge and experience exists at all levels of design, process analysis and control, and a major technology gap exists between the largest and smallest vendor industries. The project objective is to develop an integrated AI-Process Modeling Software and Hardware System capable of operating as number crunching workstations using computers such as IPSC, Mosaic, and Norvon to achieve computing speeds approaching the giga-flop speed.

PROJECT DESCRIPTION/APPROACH: The project will apply AI by using it in combination with advanced techniques form Software Engineering, Data Base Management, and Operating Systems for high speed parallel computers. The project will proceed by: (1) selecting the most appropriate parallel computer design concept, (2) splitting the process models into concurrent parts, (3) developing a general methodology for combining and dissociating split and modular application packages, (4) compiling knowledge and identifying design tasks required for simualtion, (5) developing a knowledge representation paradigm, (6) designing a material and process data base structure, (7) automating CAE/CAD/CAM tasks, and (8) providing ways to modify and upgrade the knowledge base.

IMPORTANCE TO MANUFACTURING: The development of AI-Process Modeling Systems for medium to large-grain parallel machines is paramount to implementing this proven technology in the smallest and largest U.S. parts vendors. It will: (1) improve product integrity on a repeatable basis, (2) automate process design, monitoring and control, (3) shorten the tooling development cycle, (4) extend the design scheming stage, (5) close gap between experience levels, (6) improve productivity, just-in-time part delivery and defense production surge capability, (7) reduce technology gap between vendors, (8) provide alternate part vendors, (9) create a new methodology for synthesizing new manufacturing processes in the computer, (10) solve the need for greater computational power in manufacturing at affordable cost, (11) overcome the educational barrier.

FOR WORKSHOP USE
CODE # 15

CONTINUATION OF (project title) AI for Process Design and Control Using High Speed Medium - to Large-Grain Parallel Computers

POTENTIAL PAYOFF (quantitative, if possible): (1) Lea time before production will be reduced by 25%, (2) Products will be made right the f rst time, (3) Productivity will be increased about 30%, (4) Machine utilization will increase about 50%, (5) Design scheming stage will increase by about 25%, (6) part reject-rate will decrease by about 95%, (7) Powerful CAE workstations will be affordable for ie smallest DoD part vendor, and (8) A new methodology will be created for synthesizir new manufacturing processes in the computer.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This research will provide approaches to solving the need in manufacturing for greater computational power at affordable cost, and it will create meta-experts which are not available. It will resolve the criticial technical issues which are related to computing speed and parallel computer architectures which are most suitable for merging AI with scientific and engineering problem solving methodologies and it will define the design tasks which must be accomplished by the AI software to automate problem solving and decision making.

PROJECT DURATION: 5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Evaluate Parallel Computer Architectures 0-6 months, Split FE Codes into Concurrent Parts 0-24 months, Develop Modular Modeling 12-48 months, Compile Knowledge and Identify Tasks 12-48 months, Develop Knowledge Representation Paradigm 18-48 months, Develop Material and Process Data Base Structure 0-24 months, Automate CAE/CAD/CAM Tasks 36-60 months, Provide Ways to Modify/Upgrade Knowledge Base 48-60 months.

RESOURCE REQUIREMENTS: Person Years Required: 12 (knowledge compilation = 5, knowledge representation = 3, FE Code Splitting 2, Parallelism = 2)

Hardware Required: IPSC Class Parallel Computer

Software Required: Fortran, C-Language, MLISP, TRAID-Information Analyzer and Developer, etc.

PROJECT CLASSIFICATION (please check one):

X Basic Research (long-term) ___ Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # EXTRA

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

X UNIT PROCESSES ____ MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Design Feedback from a Manufacturing Process

PROBLEM DEFINITION/PROJECT OBJECTIVE: Despite the trend toward integrating CAD & CAM tools, the transition from a drawing on a screen to a finished part is rarely smooth. Design errors, part programming bugs and imperfect knowledge of the conditions in a particular process combine to prevent NC part programs from working correctly at first. The principal problem is that there is a one-way flow of information from CAD to CAM. The objective of this project is to develop a two-way dialogue.

PROJECT DESCRIPTION/APPROACH: Two parallel efforts will be directed at establishing a dialogue between CAD & CAM in an on-campus machining application. The first effort will require developing tools to gather and interpret process data (such as machining parameters and fixture types) and to maintain the results in a relational data base. The result is knowledge base that, unlike a machinists handbook, is tuned to the local process. Rules will then be tested in an expert system (using design students as a population sample) for aiding the designer in evaluating the ease of manufacturing a design.

The second effort focuses on an intelligent, final design interface in which the designer "machines" the part on screen using virtual tools. Again, the effectiveness of specific rules will be tested on design students.

IMPORTANCE TO MANUFACTURING:

There is a basic need to reduce the leadtime in developing and producing new products. Designers need feedback from the manufacturing process to ensure that their designs make effective use of available manufacturing facilities and are cost-effective to produce.

FOR WORKSHOP USE
CODE # EXTRA

CONTINUATION OF (project title) Design Feedback from a Manufacturing Process

POTENTIAL PAYOFF (quantitative, if possible): In the long-run, the expected payoff is greatly reduced time and expense in bringing new designs to production. Delays caused by faulty part programs, poor knowledge of the ideal manufacturing conditions, too many set-ups, etc. should be greatly reduced.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Most efforts to date have focused on trying to quantify the "manufacturability" of a completed design. The current proposal is a new approach in which the designer must think about final design and part manufacture concurrently. The local data base, combined with suggestions from an expert system with knowledge of the local process, will be especially interesting to test on novice designers.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): 1) create link between existing CAD & CAM facilities so that process data is accessible by the LISP shell that currently surrounds the CAD facilities, 0-18 mo. 2) statistical data interpretation & construction of data base, 12-30 mo. 3) create interactive tool in which geometric primitives which consist of input raw materials shapes & "virtual tools" are used to achieve final design, 12-30 mo. 4) embed rules in expert system & evaluate their effectiveness on novice designers, 24-36 mo.

RESOURCE REQUIREMENTS:

(1) Principal Investigator @ 20% salary for 3 years

(2) Graduate Students for 3 years

Sensor & Interface Hardware (est. $5K)

Machine Shop & Computational Resource Access

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

SESSION #: 3

AI/WORKSHOP EVALUATION
July 31, August 1, 1985
GROUP: 1

	CRITERIA	1	2	3	4	5
PROJECT #: 1	MEAN	5.60	5.27	5.40	5.80	4.47
	ST. DEV.	1.35	1.16	1.12	1.47	1.25
PROJECT #: 2	MEAN	5.20	4.67	4.47	6.00	5.47
	ST. DEV.	1.57	1.84	1.68	1.13	1.51
PROJECT #: 3	MEAN	5.00	4.80	5.13	6.40	4.00
	ST. DEV.	2.14	2.21	1.64	1.92	1.77
PROJECT #: 4	MEAN	7.00	6.73	6.67	5.80	4.13
	ST. DEV.	.93	1.22	1.11	1.52	1.13
PROJECT #: 5	MEAN	6.73	6.00	6.33	6.40	4.53
	ST. DEV.	1.28	1.25	1.11	1.59	.92
PROJECT #: 6	MEAN	7.47	7.40	7.40	4.27	4.33
	ST. DEV.	1.25	1.24	1.30	1.44	1.54
PROJECT #: 7	MEAN	6.00	5.93	5.87	4.07	4.93
	ST. DEV.	2.07	2.31	2.33	1.75	2.31
PROJECT #: 8	MEAN	5.87	5.73	5.67	5.67	5.00
	ST. DEV.	2.10	2.34	2.16	2.02	1.46
PROJECT #: 9	MEAN	4.53	5.13	5.60	6.60	3.27
	ST. DEV.	1.51	1.41	1.50	2.16	1.33
PROJECT #: 10	MEAN	7.20	6.60	6.67	6.53	3.53
	ST. DEV.	1.26	1.24	1.18	1.19	.92
PROJECT #: 11	MEAN	5.53	5.33	5.73	6.47	4.93
	ST. DEV.	1.88	1.76	1.58	1.36	1.49
PROJECT #: 12	MEAN	7.13	7.13	6.67	5.20	3.67
	ST. DEV.	1.13	1.06	1.05	1.32	1.11
PROJECT #: 13	MEAN	6.27	6.53	5.73	3.93	4.53
	ST. DEV.	2.05	1.88	1.83	1.71	2.00
PROJECT #: 14	MEAN	7.53	7.33	7.27	5.47	4.27
	ST. DEV.	1.06	.98	1.10	1.60	1.03
PROJECT #: 15	MEAN	3.93	5.13	5.00	3.60	3.47
	ST. DEV.	1.83	1.25	1.51	1.12	1.36

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 1

PROJECT # 1

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	1	3	2	4	5	Ø	Ø
2:	Ø	Ø	1	3	4	5	2	Ø	Ø
3:	Ø	Ø	1	2	4	6	2	Ø	Ø
4:	Ø	Ø	1	2	3	4	3	2	Ø
5:	Ø	Ø	5	2	4	4	Ø	Ø	Ø

PROJECT # 2

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	1	1	4	6	2	Ø	Ø
2:	1	1	2	2	4	2	3	Ø	Ø
3:	1	1	2	3	3	4	1	Ø	Ø
4:	Ø	Ø	Ø	1	5	3	5	1	Ø
5:	Ø	1	Ø	Ø	9	2	2	Ø	1

PROJECT # 3

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	2	1	1	3	1	6	Ø	Ø
2:	1	3	1	Ø	3	2	5	Ø	Ø
3:	Ø	1	3	Ø	3	5	3	Ø	Ø
4:	1	Ø	Ø	Ø	3	2	5	3	1
5:	2	Ø	5	1	4	2	1	Ø	Ø

PROJECT # 4

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	1	3	6	5	Ø
2:	Ø	Ø	Ø	Ø	3	3	5	3	1
3:	Ø	Ø	Ø	Ø	3	3	5	4	Ø
4:	1	Ø	Ø	Ø	3	6	5	Ø	Ø
5:	1	Ø	2	5	7	Ø	Ø	Ø	Ø

PROJECT # 5

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	4	2	3	6	Ø
2:	Ø	Ø	Ø	1	6	2	4	2	Ø
3:	Ø	Ø	Ø	Ø	5	2	6	2	Ø
4:	Ø	Ø	1	Ø	4	2	4	3	1
5:	Ø	Ø	2	5	6	2	Ø	Ø	Ø

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 1

PROJECT # 6

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	2	Ø	5	5	3
2:	Ø	Ø	Ø	Ø	2	1	3	7	2
3:	Ø	Ø	Ø	Ø	1	3	4	3	4
4:	Ø	2	2	5	3	2	1	Ø	Ø
5:	Ø	Ø	7	1	4	2	Ø	1	Ø

PROJECT # 7

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	1	1	2	2	4	4	Ø
2:	2	Ø	Ø	1	1	3	4	4	Ø
3:	2	Ø	Ø	1	2	2	4	4	Ø
4:	2	Ø	3	3	6	Ø	Ø	1	Ø
5:	2	Ø	2	2	3	1	4	Ø	1

PROJECT # 8

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	Ø	3	2	3	2	3	1
2:	1	Ø	1	4	1	Ø	5	1	2
3:	1	Ø	1	3	1	3	3	2	1
4:	1	Ø	1	3	1	Ø	8	1	Ø
5:	1	Ø	1	Ø	9	2	2	Ø	Ø

PROJECT # 9

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	2	4	4	3	1	Ø	Ø
2:	Ø	Ø	1	6	2	2	4	Ø	Ø
3:	Ø	Ø	2	1	4	3	4	1	Ø
4:	1	1	Ø	Ø	Ø	1	6	6	Ø
5:	1	4	4	2	4	Ø	Ø	Ø	Ø

PROJECT # 1Ø

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	1	4	4	3	3
2:	Ø	Ø	Ø	Ø	3	5	3	3	1
3:	Ø	Ø	Ø	Ø	2	6	3	3	1
4:	Ø	Ø	Ø	Ø	4	3	4	4	Ø
5:	Ø	2	5	6	2	Ø	Ø	Ø	Ø

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 1

PROJECT # 11

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	Ø	4	2	1	6	1	Ø
2:	Ø	1	1	4	1	3	4	1	Ø
3:	Ø	1	Ø	2	3	3	5	1	Ø
4:	Ø	Ø	Ø	1	4	1	5	4	Ø
5:	Ø	1	1	3	6	2	1	1	Ø

PROJECT # 12

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	1	3	6	3	2
2:	Ø	Ø	Ø	Ø	1	3	5	5	1
3:	Ø	Ø	Ø	Ø	2	5	4	4	Ø
4:	Ø	Ø	2	1	8	Ø	4	Ø	Ø
5:	1	1	3	7	3	Ø	Ø	Ø	Ø

PROJECT # 13

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	Ø	2	2	Ø	5	5	Ø
2:	1	Ø	Ø	1	Ø	3	5	5	Ø
3:	1	Ø	1	Ø	4	2	6	1	Ø
4:	2	2	1	2	6	2	Ø	Ø	Ø
5:	2	Ø	3	Ø	6	2	1	1	Ø

PROJECT # 14

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	Ø	3	4	5	3
2:	Ø	Ø	Ø	Ø	Ø	3	6	4	2
3:	Ø	Ø	Ø	Ø	Ø	4	6	2	3
4:	Ø	Ø	1	4	4	1	3	2	Ø
5:	Ø	1	2	5	6	1	Ø	Ø	Ø

PROJECT # 15

CRIT. #	1	2	3	4	5	6	7	8	9
1:	2	2	1	4	3	2	1	Ø	Ø
2:	Ø	Ø	1	4	4	5	Ø	1	Ø
3:	Ø	1	1	3	5	3	1	1	Ø
4:	1	1	4	6	3	Ø	Ø	Ø	Ø
5:	1	3	4	2	5	Ø	Ø	Ø	Ø

UNIT PROCESSES RECONCILIATION COMMENTS

Project 1

I rate consistency low because there is very little real AI - look at milestones - mostly finite element - and the AI reference "learns to revise its rules" is absurd. Either the author refers to "adaptively modify rule parameters" which is not AI - or really means what he says and that is well beyond state-of-AI-art, thus low feasibility.

Not a very important project in terms of impact

The project looks feasible. There are already commercially available modular fixture systems.

I still feel that only lip service is given to AI. The described "learn to modify its own rules" is too far beyond the state-of-the-art.

Project 2

There are many ways to solve this problem; for example, use interchangeable grippers, designed specifically for given shapes.

Independent of "AI" natural development of solid models of objects is the availability of these models to "robot programers", and independent of "AI" natural development of vision and tactical sensors will make it "much easier" and less expensive to program where and how to grasp parts.

Too narrow in scope.

The impact of the project is limited and therefore I agree with the estimated realism.

I view the project is limited in scope and easily realizable without application of artificial intelligence.

Doing geometric redesigning is not that difficult provided the proper representations are used. (4 years of experience/dissertation in this area)

Do not consider innovative AI application; and as stated, will not improve the unit process. As pointed out in discussion, it is a "academic look at an abstract problem".

Project 3

Commercial software available ("SACON" from Teknowledge) to do this job.

Methods to achieve the objective of the project are demonstrated and known. The payoff of additional investment is not needed to stimulate the extrapolation of this concept.

The project, as explained by its author, has a different objective than the one stated in the form.

This type of expert system has been done and will become widely available without USAF funding. Therefore, feasibility is very high. I don't feel that objectives or scope were met because analysis packages are limited to a small part (i.e., design) of the total manufacturing process.

This application of expert system is state-of-the-art already. The impact and payoff are limited to those groups that use the specific combination of analysis tools. It should be a commercially funded project. Hundreds of companies are already pursuing such projects. The Air Force should put its money elsewhere.

There are already a multitude of commercial investments being made to address this area. The development is well under way and is not needing Air Force support.

Project 5

It's not clear to me that the behavior of composites is well enough understood - even at a heuristic level - to make this feasible as a 2.5 year project.

Is the knowledge all there?

There is not adequate explanation about the performance strategy of this research project.

Impact is substantial - shows up wherever models and AI both are useful for different parts of same problem.

Project 6

Project is ambitious and technically difficult.

The project is feasible if approached as a shell of intelligence that integrates discrete process through a communication facility. The real-time definition would need, in this case, to be defined in terms of minutes or seconds.

I did not change my 2 on feasibility because I believe that it will be very difficult to "...formulate (swiftly) an alternate plan"... based on sensory input.

Project 7

No technical concept about how to do this project.

The project, as stated in the form, does not have any clear objectives and technical feasibility.

Scope and deliverables of proposed project are "modest" and not too difficult as I understand them.

The guts of this system already exist in the ITA planner (macro operations, pre/past conditions, etc.). Supervised generation of these operators is a logical next step, requiring a good operator interface.

Project 8

No technical concept. Just a batch of random hardware and software. No credible approach to real-time execution (i.e., what do you do if you cannot do the problem in real-time?)

This project provides an alternative approach to the control of flexible manufacturing systems. Individual real-time processors for machine control could compete for priority directly with other processors such as material handling systems, if fast enough. An understanding of the real-time capabilities is needed.

This is a "where the rubber meets the road" issue. Until someone works through the details and "gotcha's" of putting AI machines on the shop floor, very few of these unit processing projects can be put into production. We can do it "in the lab" forever, but the bottom line depends on practical, economical, reliable vehicles for implementing these ideas in production.

This capability is badly needed for metal fab machine tools, especially in the creation of flexible manufacturing systems.

Project 9

Not an AI problem. Should design post-processor for conversion.

The problem stated is valid, however, it can be formulated as a standardization problem.

The deliverable is a requirements document. From experience in computer vision, hardware/software/systems are operating in vacuums when it comes to emerging technologies. I'm sure the same is true of AI. Identifying and bridging these voids is very feasible and needs to be done.

Project 11

Project is conventional diagnostic expert system. Minimal research content. Level of resource not justified given commercial tools availability.

It seems that before expert systems will be ripe for appreciation, major problems in sensor technology, data interpretation, and perception must be ved first.

I consider the effort high if the project excludes development or research into machine monitoring technologies.

I would suggest expanding the project to encompass tool monitoring as well.

This is a very important application for quality and machine capacity utilization.

The hard part of this project is developing reliable monitoring techniques not creating an expert system. As written, the project assumes existing monitoring techniques will be used. I therefore believe this is a relatively simply project.

I still feel that the primary hurdle in this project - as written - may not be AI hurdles.

Project 12

The proposers of this project do not plan to use "solid geometric model" data to "help" the AI system but are depending excessively on sensors for environment information that will be used for planning. Hence, technique feasibility is in question and risky.

This project implicitly assumes a working, controllable, dexertrous hand with tactile sensing - but that alone would require a considerable effort to achieve, the state-of-the-art is not there yet.

The proposer of this project makes no mention of the intent to use digital data solid models as inputs to the "planner" which might be why there is discussion of "incomplete" information. Manufacturing is not as unstructured as a battlefield, because we do have "prints" of the parts to be assembled. Not to use these "prints" makes the job -- more fun and more interesting -- but more difficult.

Project 13

Really not enough information to evaluate. My criteria is that the burden of proof is on the proposer.

The project is so far in the future as to achievability that it sums many of the projects presented.

The approach is feasible for implementing flexible manufacturing systems. Conventional vertically integrated systems could be replaced by AI based systems that make industrial decisions based on peer-to-peer communications.

Project description very vague. My interpretation is that it does not belong to this panel.

If such a capability could be developed, it would be wonderous. Hence, 8, 8, and 8 for C1, C2, and C3, but the project is so poorly defined that it is unlikely that it could even happen. Therefore, a 1 for C4. Ditto for the 1 for C5.

The projects goals are lofty hence 8's for C1, C2, and C3. But so vague that it won't happen hence a 1 for C4 and C5.

I rate feasibility very low because there simply is no adequate description of the project approach. Main thrust of project is data passing between distributed systems not advancing application of AI. Decision making priorities among intelligent nodes was not addressed either.

Project 14

Still have a problem with including "adaptive control" as an AI issue in recovering from changes in structure.

Why?

1- Adaptive control   AI
2- Changes in structure require more

I viewed the project as feasible with respect to integration of automated statistical quality control within a flexible manufacturing system. Process diagnosis could result in automatic machine compensation to keep the process within acceptable limits.

The creation of a inference engine should be straight forward and the inspection knowledge is well defined and specific; these combine to make this a very feasible project.

I view this project as providing very important contributions to AI in manufacturing at the inspection end. The project will be limited to milling and lathe operations. With this limitation, I view the technique feasibility of the project to be quite high.

Project 15

Parallel computing very important for process modeling. AI content not a major factor.

This project could be used as a framework for the entire AI institute. Changes in the formulation regarding the use of AI should be made.

I do not feel that this project defines a significant application of AI even though it would be beneficial to manufacturing advances. Therefore, its impact and payoff are not relevant to this program.

Project has very good objective but does not appear applicable to the application of AI to manufacturing. I suggest the project be reclassified as part of a computer hardware/software development group.

Parallel processing requires a completely different mode of thinking. Dealing with this question is extremely relevant.

The deliverable, as I read it, would be a total system, not just a "parallel hardware machine". Should/could such a total system be developed it would solve all our problems. Hence, a 9 for C1, C2, and C3. But to develop a total system???

The need for parallel processors is limited and industry is very slow to adopt radically different computers in manufacturing. The impact and payoff would be very high for activities such as high speed flight simulations but not manufacturing.

I see the project as highly oriented to generic parallel processing, not specific to AI in manufacture Let Mathematical Sciences Division pay for it.

The project as stated assumes parallel computation will be this answer. Not so. But the narrative outlining "Importance of Manufacturing" is a superb overview of why AI/ES applies to manufacturing applications of the Unit Process Systems level is so important to the USAF.

APPENDIX B

MANUFACTURING SYSTEMS

This appendix reflects the results from the deliberations of the Manufacturing Systems Panel. It is organized as follows:

DESCRIPTION	PAGE
Sub-Panel White Paper	B-2
Panel Specific Criteria	B-7
Candidate Projects	B-9
Round 3 Assessment Statistics	B-49
Reconciliation Comments	B-55

WHITE PAPER

FOR

MANUFACTURING SYSTEMS

DEFINITION

Manufacturing systems begin with product and supporting process design and end with the delivery of the complete definition for production and distribution. They also include generation of system metrics and measurement of system performance.

Examples of manufacturing system activities or areas of interest are:

- product definition,
- product planning,
- production planning,
- production scheduling,
- floor control,
- specification control,
- configuration management,
- tool management,
- materials planning,
- facilities layout,
- integrated design: product, process, system, etc.,
- all the non-touch labor areas, except those related to unit process operations,
- and specifying the information system needs and requirements.

MOTIVATION FOR RESEARCH

During the past 30 years, the number of people involved in touch labor in the United States has remained constant at approximately 19 million. During the same time, the output of these people has grown dramatically. Nonetheless, our overall manufacturing productivity is declining. A large contribution to this decline is the near exponential growth of non-touch labor. A major opportunity exists, therefore, to reduce product cost and increase the responsiveness of factories by improving the productivity of non-touch labor. Conversely, complete automation of the touch labor involved in actual production processes would only moderately improve total productivity or reduce product cost.

Non-touch labor is involved in the creation, receiving, sorting, transforming, and transmitting of information and decisions based thereon. Information can be thought of as the data, knowledge, and skills which exist in the data bases, filing cabinets, and people involved with manufacturing systems. Since current data processing approaches have not adequately addressed the information acquisition, management, and use issues

involved in manufacturing, a new approach is needed. Because of its ability to deal with the complex information and decision making issues involved in manufacturing systems, artificial intelligence promises to make non-touch labor more efficient and thus dramatically improve productivity.

In addition, other factors motivating research in the area are:

- a need for a unified interdisciplinary approach,
- insufficient, on-going research available (critical mass required),
- a need to expand the education base,
- the maintenance of national leadership in technology,
- a desire to accelerate technology,
- a need for cost competitiveness (reduced cost of system development),
- the desire to manage change and complexity,
- a need for improved decision/configuration management,
- and a desire to capture expertise.

WHY AI?

The constraint propagation properties of manufacturing problem solving match the problem characteristic requirements of most AI techniques. Consequently, there is a natural relationship that exists between the problem structure of the manufacturing system and the structure requirements of AI techniques.

Manufacturing is a nearly decomposable system in that it consists of loosely coupled subsystems. The interactions between the subsystems are in the form of constraints that:

- express existing relationships among subsystems by specifying conditions to be satisfied, and
- express commitments that can be made as a result of satisfying a condition.

The overall system goal is to manufacture a product on time and within budget that meets specifications. This goal is decomposed into subsystem goals and working backwards through constraint satisfaction, the overall goal is met. The constraint propagation leads to a least commitment planning strategy that defers decisions as long as possible in meeting the goal.

Characteristics of AI techniques that facilitate the planning activities of manufacturing include:

- conflict resolution,
- coping with uncertainty in data and knowledge,
- dealing with complexity and ill-structuredness,
- pooling of expertise,
- and exception handling.

WHERE AI?

There are AI systems at early stages of development in many manufacturing system problem areas including product and facilities design, scheduling, distribution, field service, and strategic management. Prime problem types for current application are diagnosis and structured selection. Other problem types such as planning, design, and model-based reasoning require additional research breakthroughs to provide the necessary reasoning power for fully addressing them.

A conceptual framework of possible applications of AI to manufacturing system problems is given in Figure 1. This framework was generated at the November 1984 workshop by the Manufacturing Systems Panel and provides an evaluation of manufacturing decision-making levels and their characteristics with regard to AI applications.

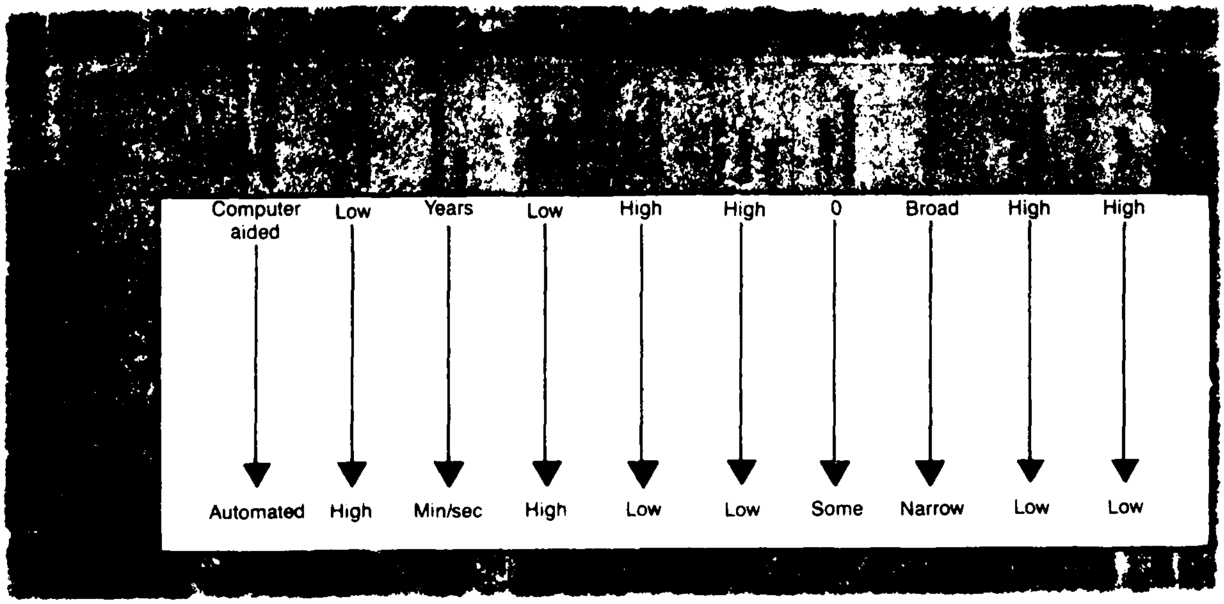


FIGURE 1: MANUFACTURING SYSTEM DECISION-MAKING LEVELS AND CHARACTERISTICS WITH REGARD TO AI APPLICATIONS

LIMITATIONS/EXPECTATIONS

AI is an emerging technology which is in its first generation of commercial products and applications. This means the product definition and appropriate manufacturing application are still being defined. Thus, the methodology currently used to solve real problems is incremental prototyping. The use of the technologies is limited by a lack of seasoned practitioners; thus, there is a real requirement for educational programs that help prepare industry for the fusion of this technology into existing methods of manufacturing operations. Most current tools are extensions of

research prototypes and are not turn-key systems. They suffer from poor documentation, lack of interface standards, corporate support services, and extensive use in wide ranging applications.

The limitations of the initial systems were that they were not general purpose systems and they focused on analytical/diagnostic processes and problems. These systems are not easily interfaceable to traditional data bases. Future systems should provide the capability for problem synthesis and have more general purpose functionality.

Managing the expectations of senior manufacturing management and the end user community is a critical task in order to provide the effective transfer of these new AI technologies within the manufacturing operations. It is not expected that the technology will create large displacements or disruptions in manpower but rather will augment/enhance their decision making and thus free up their time to focus on problems and issues not easily codified or automated. There is an expectation that these systems are capable of self-learning and can build models; however, the current generation of tools cannot. This is a major research area. Consequently, the expert will be needed to maintain the system for years to come.

Another expectation is that since the systems involve capturing the expertise of in-house experts, they can be developed quickly and painlessly. However, a current bottleneck in applying the technology is acquiring the knowledge and properly representing the knowledge that constitutes the expertise. There is also the need to allocate large amounts of the experts' time to the system development process. These activities require the dedication of full-time staff to learn the AI languages, methodologies, disciplines, understanding the development environments, and computational requirements.

Problems that don't address a real need and are not sufficiently bounded have a high probability of failure. The risk of failure can be reduced through realistic management of expectations, end user involvement throughout the system design cycle, and an incremental approach to solving the problem.

There are a number of hard and intractable problems where extensive research efforts must be brought to bear to gain insight to possible solutions. These problems are:

- machine understanding of human discourse,
- self-learning systems,
- self-modification by the system,
- knowledge representation,
- knowledge acquisition processes,
- automated expert system generators,
- and programming paradigms for parallel processors.

GOALS

The goals for supporting research in the application of AI to manufacturing systems include: strengthen national competitiveness by improving quality, productivity, reaction time, and cost effectiveness of batch manufacturing parts; contribute to the science and technology base supporting this area; and provide educational opportunities that expand the pool of people skilled in this area.

OBJECTIVES

The objectives are:

- Provide a framework for allowing total design and manufacturing integration.
- Provide improved tools for all elements of planning, scheduling, and controlling factory operations.
- Foster co-residency of AI based and traditional methods.
- Develop effective means for capturing, transmitting, and using manufacturing information.
- Establish common measures of effectiveness and efficiency of advanced manufacturing systems.
- Foster major advancements in AI methods and tools as they apply to manufacturing systems.
- Support problem driven research in such areas as reducing span time from concept to production, reducing inventories, increasing scarce resource utilization, etc.
- Demonstrate prototype developments.
- Establish a life-cycle definition and procedure for AI development programs.
- Increase the number of trained AI practitioners and educators involved in manufacturing systems.
- Foster technology transfer and commercialization of research results.

MANUFACTURING SYSTEMS PROJECT ASSESSMENT CRITERIA

USE THE FOLLOWING SCALE FOR CRITERIA 1 THROUGH 4

1	2	3	4	5	6	7	8	9
Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree

C1. FEASIBILITY - The project is feasible in that the problem is sufficiently understood and the approach sufficiently promising to determine if a solution is achievable and objectives can be met.

C2. IMPORTANCE TO MANUFACTURING - This project is significant in its contribution to the desires of the manufacturing community. Specifically, it exhibits breadth of utility across the manufacturing industry, applies to a variety of opportunities across manufacturing systems, and enables manufacturing systems organizations to achieve new capabilities.

C3. PAYOFF - The project exhibits potential for payoff in manufacturing. Payoff has two major attributes: return on current investments, and investment in future potential capabilities. Return of current investments requires the project be truly implementable with designated deliverables, milestones and quantifiable measurements of improvement for a current manufacturing need. Investment in future potential capability provides a process to research areas of uncertainty and high risk, but usually infers significant high payoffs by providing answers to research questions. It is assumed that where there is existing intense investment in R/D areas, that the future investment here should build upon the current effort, not reinvent it.

C4. CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE - The results of this project provide an original or innovative contribution to the understanding, methodologies, or tools needed to develop artificial intelligence applications for solving manufacturing systems problems.

USE THE FOLLOWING SCALE FOR CRITERIA 5 AND 6

1	2	3	4	5	6	7	8	9
Very Low		Low		Agree		High		Very High

C5. TIME ESTIMATE - The time estimate (in calendar years) is reasonable in light of the project's objective and approach.

C6. RESOURCE ESTIMATE - The resource estimate is reasonable in light of the project's objectives and approach.

FOR WORKSHOP USE
CODE # 1

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES   X MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Material Handling Equipment Selection Expert System

PROBLEM DEFINITION/PROJECT OBJECTIVE: To develop an expert system that aids in the selection of specific handling equipment for a given material handling task. That is selection from a list of M/H equipment options to move a load unit with some given attributes from one location to another location. The objective of this project is to develop a rule base that incorporates "generic" rules, "site-specific" rules, and "meta-rules" that direct the problem analysis.

PROJECT DESCRIPTION/APPROACH: A rule base will be developed containing the equipment selection decision rules of human experts. Because the knowledge needed for a variety of equipment types is not commonly available in a single human expert, multiple experts will be used in gathering expertise. It is intended that this system be used to support both new facility design (and retrofit) and frequently recurring M/H selection decisions in existing facilities. Elements of the project include knowledge acquisition and integration, knowledge representation design, design of communication dialog, and test/verification/validation/demonstration of the system.

IMPORTANCE TO MANUFACTURING: The facilities engineer that needs to choose material handling equipment does not often have available or understand the range of equipment alternatives that exist and where they are best fitted. This problem occurs across a broad spectrum of industry. (It is intended that this tool be adaptable to a variety of industrial sites.) The proposed system would allow the facilities engineer to easily evaluate the available alternatives.

FOR WORKSHOP USE
CODE # 1

CONTINUATION OF (project title) Material Handling Equipment Selection Expert System

POTENTIAL PAYOFF (quantitative, if possible): Poorly chosen material handling equipment can be costly and adversely affect manufacturing system productivity. The benefits from available expertise for material handling equipment selection could be realized at frequent planning intervals with some companies using such a tool on a weekly basis. Eventual additional payoff would come in a more sophisticated system that selects material handling "systems".

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Contribution would be primarily in the technology base in a form of a software tool for material handling equipment selection including selection knowledge and a data base of available equipment types. It would also provide an educational tool for material handling.

PROJECT DURATION: 1.0 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Demonstrate prototype for cranes, trucks, and conveyor selection in 9 months.

RESOURCE REQUIREMENTS:

(1) Knowledge Engineer		.75 MY
(3) Experts in Material Handling Equipment Selection		.30 MY
(1) Project Director		.10 MY
(1) Microcomputer	TOTAL	1.15 MY
(1) Knowledge Engineering Tool		

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) ____ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 2

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES X MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Realtime Control of Cell-Level Batch Manufacturing

PROBLEM DEFINITION/PROJECT OBJECTIVE: Current control systems only automate material handling and NC program down-loading because the nature of automated batch manufacturing generates large numbers of exceptions. These exceptions are currently handled manually by the system supervisor using a decision support tool. The project objective is to build a control function as well as the exception handling using artificial intelligence techniques.

PROJECT DESCRIPTION/APPROACH: The approach is a phased development in which a standard control architecture would be augmented with AI and evaluated to understand the problems and technology gaps. The results would be used to structure technology developments to enable the control system to be built using a new structure based upon unique approaches suitable to the properties of AI techniques.

IMPORTANCE TO MANUFACTURING: The manufacturing system expects a certain level of intelligence from the cell. This is currently provided by the supervisor who acts as a cognitive buffer between the cell and the rest of the manufacturing system. This project addresses the cells cognitive needs and would eliminate the requirement for the man-in-the-loop operation.

FOR WORKSHOP USE
CODE # 2

CONTINUATION OF (projecttitle) Realtime Control of Cell-Level Batch Manufacturing

POTENTIAL PAYOFF (quantitative, if possible): These results would allow the cell to act as a truly felxible manufacturing system and process multiple part types dynamically without the significant manual planning needed to support current systems.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: AI has not been successfully applied to complex realtime systems in a manufacturing environment. This project would identify the key problem and technology issues and provide a proof of concept for their solution.

PROJECT DURATION: 7 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (1) Build the control system using a standard architecture, 1½ yrs (2) Define the technology issues, 2 yrs (3) Solve the technology issues, 4 yrs (4) Design a new AI based control architecture, 6 yrs (5) Build a prototype for proof-of-concept demonstration, 7 yrs.

RESOURCE REQUIREMENTS: Cell emulator development, with attached AI processor, software - $200,000 for equipment, 2 senior researchers and 4 graduate students for 7 years - 10 manyears.

PROJECT CLASSIFICATION, (please check one):

X Basic Research (long-term) ___ Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near term)

FOR WORKSHOP USE
CODE # 3

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES   X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Engineering Change Management

PROBLEM DEFINITION/PROJECT OBJECTIVE: In a batch manufacturing aerospace environment, Engineering Change (EC) Management is difficult due to the large number of engineering change requests associated with the product through its entire production life cycle. This project would build an AI based system to perform configuration management.

PROJECT DESCRIPTION/APPROACH: The system would monitor work orders and active change requests continually to ensure a pending operation uses the most recent EC and that any EC currently active on previous operations are reflected in the parts. Since this is exception management, it is well suited to AI techniques. However, it also requires the system to be integrated into the shop floor control system and the manufacturing data base.

IMPORTANCE TO MANUFACTURING: A great deal of scrap results from part spoilage through unintentional use of dated engineering specifications. This is a result of poor engineering change management. An automated system would reduce this scrap and ensure the delivered product met customer specifications.

FOR WORKSHOP USE
CODE # 3

CONTINUATION OF (project title) Engineering Change Management

POTENTIAL PAYOFF (quantitative, if possible): The potential payoff is a reduction in rework and scrap due to the unintentional use of improper engineering design specifications. It would eliminate the current practice of generating the manufacturing bill of materials for a specific ship set from the completed product.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The design and implementation of a system capable of automatically handling thousands of active EC relating to tens of thousands of parts would provide the technology development necessary to implement AI in large on-time production environments integrated with the existing manufacturing systems.

PROJECT DURATION: 4 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Define the EC problem - 1 yr; define the AI-EC requirements & design specifications - 1½ yr; design & implement, test and install - 4 yrs

RESOURCE REQUIREMENTS: 50 manyears

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) X Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 4

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Shop Floor Scheduling System

PROBLEM DEFINITION/PROJECT OBJECTIVE: This Intelligent Shop Floor Scheduling System will provide the following capabilities: more efficient utilization of resources; better visibility of event status; queing reduction,; fast response to changes within the operations.

PROJECT DESCRIPTION/APPROACH: A specific manufacturing process will be selected. Flow chart the process as the first step in the knowledge acquisition process. Select the appropriate knowledge representation schemes. Start the base shell of the Knowledge Based System, and continue incrementing the base prototype with knowledge acquisition, and expanded representations. Demo the base shell early. Ensure the base system can interface to existing manufacturing information system data bases. A base assumption here is that there are existing manufacturing data bases of high integrity and accuracy.

IMPORTANCE TO MANUFACTURING: This system will have wide industrial applicability from the smallest shop to large corporation plants. It will provide flexibility and high responsiveness to changes. This system would be portable to many locations.

FOR WORKSHOP USE
CODE # 4

CONTINUATION OF (project title) Intelligent Shop Floor Scheduling System

POTENTIAL PAYOFF (quantitative, if possible): Reduction in manufacturing cycle time by 30%. Improved handling process (10% less defects), reduction of WIP by 35%, increase non-touch labor productivity by 28%, and improved decision response time by 40%, with improved shipment schedules.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: New software structures for knowledge representation. New methods for fusing expert system knowledge bases and tradition manufacturing information system.

PROJECT DURATION: 3½ CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Selection & flow chart of process-3/4 yr.; design the bare shell-1 yr.; demo 1-1¼ yr; expanding the shell-1½ yr.; demo the shell 2-2 yr.; design test-2¼ yr.; interface to existing DB-3 yr.; put into production trial-3¼ yr.; final acceptance-3½ yr.

RESOURCE REQUIREMENTS: Ten manyears, availability of VAX 11750 system or equivalent.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 5

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES   X MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Generative Process Planning for Manufacturing

PROBLEM DEFINITION/PROJECT OBJECTIVE: This project would minimize the quality problems, schedule slippages, resource overloads, high part scrap rates and shop congestion conditions that are currently a part of the manufacturing environment. It would be designed for effective standardization and consistency between generated plans. This system would accept, as input, a coded description of the relevant characteristics of the part to be planned and produce a process plan for that part. Such an application would "read" the part geometry and part description information and create the coded description through the interface to CAD data base systems.

PROJECT DESCRIPTION/APPROACH: This project requires an integration with both the engineering design system and the manufacturing system. It requires the development of complex knowledge representation schemes to represent the relationship between part feature characteristics and properties and the manufacturing processes and resources. The actual planning activities are sufficiently complex to require significant advancement in the understanding of the general planning process.

IMPORTANCE TO MANUFACTURING: It would use search strategies to implement goal seeking capabilities. That is, the system could use backtracking stragegies to produce plans which minimize set-up and/or maximize the use of particular sets of machines, for example.

FOR WORKSHOP USE
CODE # 5

CONTINUATION OF (project title) Generative Process Planning for Manufacturing

POTENTIAL PAYOFF (quantitative, if possible): This project will reduce the effects of those required experienced in individuals who are retiring and are also in short supply. As well as promoting the effective integration of CAD/CAM into the manufacturing environments.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This project will provide extended capabilities to generate classification structures from CAD data bases which currently presents a significant void in this technology area. It would also extend the understanding of the general planning process and how it can be automated.

PROJECT DURATION: 10 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Identify the generic data structures and knowledge representation requirements, 5 yrs.; analyze & define the planning system used by manual planners - 5 yrs.; determine how to automate the planning system, the knowledge representation scheme & their dynamic interaction - 8 yrs.; determine how to analyze CAD data to generate the knowledge - 7 yrs.; design & build the prototype - 10 yrs.

RESOURCE REQUIREMENTS: 50 manyears

PROJECT CLASSIFICATION (please check one):

X Basic Research (long-term) ___ Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

CODE # 6

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

_X_ MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Software Tools for System Scheduling

PROBLEM DEFINITION/PROJECT OBJECTIVE: Each manufacturing system has configuration and scheduling problems unique to its environment these can be caused by physical constraints, personnel and equipment availability or supplier reliability. The objective of this project is to develop software tools with the capability of representing a large variety of manufacturing systems and developing an expert configurer and scheduler for each system.

PROJECT DESCRIPTION/APPROACH: Initially one would build a skeletal inference system which would consist of a method of representing the processes in the manufacturing system and some general meta-rules for developing scheduling experts systems. The process representation would be a frame based system with a frame for each process. Slots would contain cost of operation, retooling costs, suppliers etc. Overall system inputs would include supplier rates and desired output rates. When a user has input his particular system the software will then build an expert configurer and schedule.

IMPORTANCE TO MANUFACTURING: The flexibility of such a system will allow the representation of manufacturing systems from unit processes to plant level networks. The availability of such software will make the AI techniques available to a large community. Any change in supply output requirements or capabilities in the system would cause the expert to reschedule processes to maximize utility. Along with intelligent rescheduling the system can be used as tools for acquistion decisions.

FOR WORKSHOP USE
CODE # 6

CONTINUATION OF (project title) Software Tools for System Scheduling

POTENTIAL PAYOFF (quantitative, if possible): The payoff is two-fold. For a particular manufacturing system an expert scheduler will improve product through out while minimalizing the effect of equipment malfunction and supply shortage. Moreover in developing general tools this technology becomes widely applicable.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

(1) Development of general knowledge representation scheme for manufacturing processes.
(2) Development of meta-system for automatic expert system building.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

(1) Development of knowledge representation scheme 1/2 year
(2) Construction of network constructing software 1/2 year
(3) Determination of meta-rules for automatic rule based system construction
(4) Integration and testing

(3)–(4): 2 years

RESOURCE REQUIREMENTS: 2 senior researchers 1/2 time for 3 years
3 graduate students for 3 years
2 AI workstations

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)
___ Exploratory Development (mid-term)
X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 7

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES   X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Expert System Based Simulation Model for Flexible Manufacturing Systems (FMS) Design

PROBLEM DEFINITION/PROJECT OBJECTIVE: There are currently three approaches to evaluating design proposals for flexible manufacturing systems: full scale implementation, pilot implementation, and computer simulation analysis. Of these methods, simulation is the most efficient; unfortunately, because of the level of expertise required, simulation has not achieved its potential as a design tool. The objective of this project is to embed a process design expert system in an FMS simulation model thus permitting designers to easily obtain acceptable designs.

PROJECT DESCRIPTION/APPROACH: From emerging FMS simulation model literature, a generic FMS definition will be developed. Key operational and financial performance measures for FMS will be identified from the generic FMS definition. The FMS definition will be analyzed to develop a knowledge base of performance/cost tradeoff relationships. Design principles, practices, and rules of thumb will be identified from available design sources, e.g., literature, engineering standards. An expert system using the knowledge base of design relationships and the design rules will be embedded as a control mechanism in an FMS simulator to guide the simulator toward acceptable design options.

IMPORTANCE TO MANUFACTURING: Some types of performance/cost evaluation is accomplished for every proposed FMS design. The evaluation may be an intuitive assessment of potential or a detailed analytical study, but every proposal is evaluated in some way. If an efficient approach to identifying designs which are acceptable with respect to both operational and financial performance objectives were available to process designers, it would surely dominate evaluation approaches. Thus the technology proposed has the potential of impacting practically every future FMS implementation.

FOR WORKSHOP USE
CODE # 7

CONTINUATION OF (project title) Expert System Based Simulation Model for Flexible Manufacturing Systems (FMS) Design

POTENTIAL PAYOFF (quantitative, if possible): It is estimated that 1% of FMS implementation costs are spent on design evaluation studies. The actual alternative evaluation phase of simulation analysis represents approximately 20 percent of the analysis effort. It is expected that this could be cut in half with the proposed technology, hence the potential payoff of the technology is .1 of 1% of the implementation costs for all FMS for which the technology is used.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This project represents the first attempt to use an expert system to guide a process design simulator toward acceptable solutions. The methodology could significantly contribute to simulation technology by defining an optimum solution seeking mechanism for simulation models in general.

PROJECT DURATION: 2.5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

I. Develop a generic FMS definition. 4 months

II. Identify key operations and financial performance measures. 2 months

III. Develop performance/cost relationship knowledge base. 6 months

IV. Identify design principles, practices, guidelines. 6 months

V. Develop code for the expert system and simulator. 12 months

VI. Evaluation and testing. 6 months.

RESOURCE REQUIREMENTS: This project would require approximately 5 manyears of technical effort; AI computing and laboratory facilities for the duration of the project would also be required. A total project budget of $600,000 is anticipated.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

CODE #: 8

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES XX MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Utilization of Expert Systems in Manufacturing As Training Tools.

PROBLEM DEFINITION/PROJECT OBJECTIVE: As more and more Automation and Artificial Intelligent/Expert Systems are implemented in Manufacturing, the new people on the Shop Floor are not able to experience the proper "scenarios" to completely understand the environment. The project objective is to use the production expert systems as a training aid and to instruct people on the shop floor logic of decision processes.

PROJECT DESCRIPTION/APPROACH: Take existing Expert Systems and add the software necessary to interactively instruct and to be able to play 'what-if' games in a controlled, training environment.

IMPORTANCE TO MANUFACTURING:

1. Give people trust in some of the 'black boxes' that they use.
2. Introduce people to the functions of the shop floor in a controlled environment.
3. Train new supervisors/operators in shop floor logic.
4. Give new people the ability of seeing what impact different decisions have without affecting the shop floor.

CODE# 8

CONTINUATION OF (project title) Utilization of Expert Systems in Manufacturing As Training Tools.

POTENTIAL PAYOFF (quantitative, if possible):

- o Faster Training
- o Better man/machine interface
- o More productive people, faster
- o Better acceptance of new technology

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

- o Software tool for training in new technology

PROJECT DURATION: 2.0 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

- o 6 mo - project definitions, selection, design
- o 8 mo - coding, interfacing with existing Expert System
- o 6 mo - training, interacting and validating
- o 4 mo - user test & evaluation

RESOURCE REQUIREMENTS:

Training Specialist	2.0 my
Computer Scientist	2.0 my
Coding	1.0 my

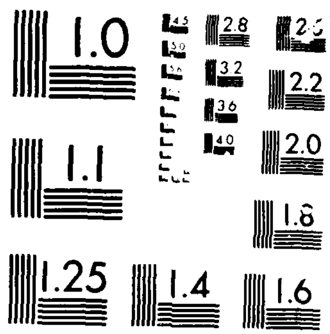
PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) XX Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

AD-A168 692 A RESEARCH PLANNING ASSESSMENT FOR APPLICATIONS OF ARTIFICIAL INTELLIGENC..(U) UNIVERSAL TECHNOLOGY CORP DAYTON OHIO W M HENGHOLD ET AL. JAN 86 2/3

UNCLASSIFIED AFWAL-TR-86-4018 F33615-83-C-5077 F/G 13/8 NL


1.0
2.8
2.2
3.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

FOR WORKSHOP USE
CODE # 9

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

x MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Manufacturing Planning and Scheduling Using Integrated AI and OR Methodologies

PROBLEM DEFINITION/PROJECT OBJECTIVE: Definition/Objective: The objective of this project is to develop methodologies and software which support the unification/integration of Operations Research and Artificial Intelligence methodologies as applied to manufacturing planning, scheduling, and analysis.

PROJECT DESCRIPTION/APPROACH: This project will evaluate the potential for the interface, integration, and unification of OR techniques with the languages of AI. Project tasks will include the evaluation of opportunities, the evaluation of existing procedures/methods, development of new methods, prototype software, and demonstrations of OR-AI integration. Particular emphasis will be placed on the opportunities relating to expert system development. OR techniques which are known to be effective in supporting manufacturing analyses (e.g., inventory theory, queueing theory, simulation, optimization) are to be used in a complimentary nature either in descriptive or in prescriptive contexts.

IMPORTANCE TO MANUFACTURING: Operations Research tools offer a significant capability for performing manufacturing analysis, planning, and scheduling. An effective mechanism for taking advantage of these tools could complement the analytic potential of expert systems and offer the opportunity to directly integrate existing manufacturing models and analyses into expert systems. In addition, the ES could provide expert guidance in the development, maintenance, and application of the OR analyses and models.

FOR WORKSHOP USE
CODE # 9

CONTINUATION OF (project title) Manufacturing Planning and Scheduling Using Integrated AI and OR Methodologies

POTENTIAL PAYOFF (quantitative, if possible): A more effective use of OR methods and models; the union of symbolic and quantitative methods will provide a widely applicable vehicle for the development of expert systems.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Contribution would be primarily in the technology base in the form of a set of software tools and methodologies for the development of symbolic based/quantitative based expert systems.

PROJECT DURATION: 2 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Conceptual design for integration, prototype software development, development of a demonstration expert system.

RESOURCE REQUIREMENTS: 6 manyears

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 10

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES   X MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Machine Monitoring Expert System

PROBLEM DEFINITION/PROJECT OBJECTIVE: This Machine Monitoring Expert System will provide monitoring of manufacturing equipment to detect changes in operational status that indicate maintenance and repair are needed.

PROJECT DESCRIPTION/APPROACH: Impending bearing failures have been detected in rotating machinery from changes in the frequency response spectrum of accelerometers used as detectors. This system would combine the AI techniques of expert systems with the machine monitoring technologies. The system would detect imminent failures, diagnose them and suggest corrective action.

IMPORTANCE TO MANUFACTURING: This system would improve maintenance and thus reduce the overhead or non-touch labor in manufacturing. By monitoring the operational status on a short periodic basis and detecting imminent failure the problem can be corrected on a non-critical time. This avoids the cost of a machine that breaks down in the middle of a production run.

FOR WORKSHOP USE
CODE # 10

CONTINUATION OF (project title) Machine Monitoring Expert System

POTENTIAL PAYOFF (quantitative, if possible): Reduction of maintenance costs, reduction of down time during production and thus higher productivity from the manufacturing facility.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Application of AI to maintenance management. Capturing the knowledge of maintenance experts in a knowledge base.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): First year - build knowledge base; Second year - build a prototype system for rotating machinery; Third year - build a generic system to allow for a wide variety of machines, sensors, and detection data for general application.

RESOURCE REQUIREMENTS: 5 man years

PROJECT CLASSIFICATION (please check one):

__ Basic Research (long-term) __ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 11

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

xx MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Shop Floor Scheduling with Resource Constraints

PROBLEM DEFINITION/PROJECT OBJECTIVE: Consider the situation in which there exists a set of workers, X, jobs, Y, facilities, Z, and times, T. Although many mathematical models and variants have been proposed (often integer programs), in practice, constraints and time limitations of a real operating environment, invalidate these approaches. An expert "somehow" accounts for reality.

PROJECT DESCRIPTION/APPROACH: A Department Head in a university setting must allocate faculty (X) to courses (Y) in classrooms (Z) during periods of the day (T). Certain "rules" are often implicitly developed to assist in this task. This seems to be analogous to a manufacturing setting and, initially, more easily structured than all the possible variants in manufacturing. Since there should be at least one "expert" in attendance relative to these matters (the writer), its examination should be facilitated.

IMPORTANCE TO MANUFACTURING: In any batch manufacturing operation, resources must be allocated in some manner to meet production and delivery requirements in a timely fashion. With more automated facilities being acquired, there are decisions to be made on how to allocate jobs between the new and old equipment when each worker, job and machine have different flexibility, capability and availability.

FOR WORKSHOP USE
CODE # 11

CONTINUATION OF (project title) Shop Floor Scheduling with Resource Constraints

POTENTIAL PAYOFF (quantitative, if possible): Often times, the final dispatching task is the responsibility of a foreman with 25 years experience. The "factory of the future" may not provide the opportunity for training these "foremen." An expert system (software) may be necessary to manage the new hardware.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Scheduling of limited resources is a generic issue in almost all human endeavors. Moreover, there is a large cadre of scientists in the Decision Sciences who are looking for a link between formal mathematical models and AI/Expert Systems. Scheduling problems could be that link.

PROJECT DURATION: 2 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

- Literature Survey (3 months)
- Rule Generation (6 months)
- Integration into Inference Engine (6 months)
- Debugging/Testing (3 months)
- Final Evaluations/Testing (6 months)

RESOURCE REQUIREMENTS:

- VAX 11/780
- 2 man-years

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

XX Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 12

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES

X MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Designing Appropriate Scheduling and Control Systems

PROBLEM DEFINITION/PROJECT OBJECTIVE: Present research focuses on control systems which can effectively interface with manufacturing schemes. These approaches often do not consider that the most appropriate approach may be to design more effective manufacturing organizations which are simpler to schedule and control. The objective of this project would be to specify a manufacturing system based upon cellular manufacturing and then to design appropriate scheduling and control systems for this environment.

PROJECT DESCRIPTION/APPROACH:

(1) Specify the manufacturing entity, in a generic sense if possible.

(2) Determine the systems information requirements necessary to schedule and/or control this entity.

(3) Design an appropriate data base for these information requirements.

(4) Propose and test scheduling and control schemes which can react in the time frames necessitated by this manufacturing entity.

(5) Interface the scheduling and control schemes, using AI, with hardware into an integrated manufacturing process.

IMPORTANCE TO MANUFACTURING:

(1) Develop a more competitive manufacturing posture.

(2) Overall manufacturing cost reductions.

FOR WORKSHOP USE
CODE # 12

CONTINUATION OF (project title) ______________________

POTENTIAL PAYOFF (quantitative, if possible):

(1) Simpler control methodologies resulting in less complex operational systems.

(2) Reduction of information processing and paperwork requirements.

(3) Overall reduction of manufacturing costs.

(4) Increased flexibility in manufacturing capabilities.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

(1) Quantifying effects (processing costs, information processing times and of alternate manufacturing configurations.

(2) Assisting in determining levels and criticality of manufacturing data required to support control activities.

PROJECT DURATION: 4 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

(1) Specification of manufacturing organization	(6 months)
(2) Data Base Requirements	(6-8 months)
(3) Simulation Model(s) Building and Testing	(9 months)
(4) Scheduling and Control Algorithms Development; Development of AI approaches.	(6-9 months)
(5) Interfacing Control schemes with simulation model; testing and refinning.	(3-6 months)
(6) Interfacing developed system with actual hardware substitutes to demonstrate applicability.	

RESOURCE REQUIREMENTS:

Scheduling Specialist; Software Development Specialist, Manufacturing Systems Specialist; Access to both mini and mainframe computer resources; computer support personnel;

PROJECT CLASSIFICATION (please check one):

Basic Research (long-term) X Exploratory Development ([illegible]-term)

Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 13

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Purchasing Support System

PROBLEM DEFINITION/PROJECT OBJECTIVE: To develop an intelligent system that can aid the purchasing function in such areas as:

- make or buy analysis
- vendor selection
- vendor performance evaluation
- combining of purchase requirements

PROJECT DESCRIPTION/APPROACH: This project is a long-term research effort to combine rule-based systems, knowledge-based systems, and traditional purchasing data bases. Multiple experts need to be used in the development of this system. The variety of the purchasing functions is the cause for this being a long-term effort.

IMPORTANCE TO MANUFACTURING: Purchased material represents a major portion of manufacturing costs. Therefore, any improved quality in purchasing decisions, will result in significant cost, quality, and delivery improvements.

FOR WORKSHOP USE
CODE # 13

CONTINUATION OF (project title) Intelligent Purchasing Support System

POTENTIAL PAYOFF (quantitative, if possible):

- Reduction of the costs of purchased material.
- Improvement of the quality of purchased material.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

- Combination of traditional, existing systems with the new expert systems technology.
- Putting it all together in one place (system) and making the expertise available to the decision makers.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

Year 1 - Scope and definition of purchasing functions.
Year 2 - Search for expertise and extraction of existing knowledge.
Year 3 - Development of prototype system.

RESOURCE REQUIREMENTS:

10 Manyear of knowledge engineering and AI programming
3 Manyear of purchasing experts.

PROJECT CLASSIFICATION (please check one):

X Basic Research (long-term) ___ Exploratory Development (mid-term)
___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 14

CONTINUATION OF (project title) Expert Systems for Design and Analysis of Life Tests and Accelerated Life Tests

POTENTIAL PAYOFF (quantitative, if possible): This project will help ensure the matching of desired life characteristics of product with the actual product, will lessen manufacturing costs, and lessen re-work and re-design costs.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This project will contribute to the integration of management, manufacturing life characteristics, information requirements for testing and testability, and engineering design.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Analyze and define the design requirements for testability and life characteristics; construct the sampling scheme for the field - design - testing requirements; endow the analysis and experimental design programs with intelligence.

RESOURCE REQUIREMENTS: 5 man years
$100,000 equipment

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) ____ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 14

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES

X MANUFACTURING SYSTEMS

___ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Expert Systems for Design and Analysis of Life Tests and Accelerated Life Tests

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective is the development of an expert system which aids in the design of life and accelerated life tests, performs the analysis of the results of the tests, assesses the results and internal consistency of the results, evaluates warranty times, and makes suggestions as to the need and advisability of further tests.

PROJECT DESCRIPTION/APPROACH: The project integrates the engineering design and manufacturing activities concerning the production of various products. In particular an emphasis is placed on design for testability and on integration of quality control across the spectrum of manufacturing activities. Experimental design and response surface methodologies would play a prominent role in the project. Sampling strategies for following product in the field will be developed for the maintenance of an intelligent information system.

IMPORTANCE TO MANUFACTURING: The project ensures that the life characteristics of the final product are brought back to the design stage so that one of the most important of all feedback loops in manufacturing is explicitly involved in the manufacturing endeavor.

FOR WORKSHOP USE
CODE # 15

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Integration of Statistical Capabilities, AI, and a Simulation Language

PROBLEM DEFINITION/PROJECT OBJECTIVE: This project would merge statistical summarization, graphics, and analysis software, and artificial intelligence with respect to planning, analysis, interpretation, and subsequent modification into a current simulation language, namely GPSS.

PROJECT DESCRIPTION/APPROACH: Much of the software for the statistical and experimental planning aspects of this project are already available. The marriage of the existing softwares and endowing the result with intelligence will require a Pareto-like analysis scheme to make the result generally useful.

IMPORTANCE TO MANUFACTURING: The resulting software will have extensive industrial application in facilities design and the development of flexible manufacturing systems.

FOR WORKSHOP USE
CODE # 15

CONTINUATION OF (project title) Integration of Statistical Capabilities, AI, and a Simulation Language

POTENTIAL PAYOFF (quantitative, if possible): Reduction in design costs, increased capability and productivity for design personnel, and improved decision response time.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: New methods for integrating simulation procedures, artificial intelligence, and design of systems.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): Marriage of the simulation language and statistical summarization and analysis packages, 1 year; endow intelligence, 2 years; enhance capabilities, 2 3/4 years.

RESOURCE REQUIREMENTS: 6 man years
$100,000 equipment, software

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 16

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

XX MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Rule-Based Process Diagnosis

PROBLEM DEFINITION/PROJECT OBJECTIVE: The quality control problem in a manufacturing system can be decomposed into three subproblems: recognizing a change in system behavior (inspection); explaining the behavioral change in terms of changes to the system structure (diagnosis); and recovering from the changes in the system structure (adaptive control). The objective of the project is to develop a feasibility demonstration diagnosis system that will generate explanations of observed part quality problems in terms of defects in the unit processes that produced the part. Thus, it will serve as a bridge between the part inspection and process control functions of a manufacturing system.

PROJECT DESCRIPTION/APPROACH: A rule base will be developed to model the causal relations of unit processes and parts. The model will relate symptoms (inspection data) to process states, and relate process states to physical defects in the process. An inference engine will be developed to explain part defects in terms of defects in one or more processes involved in manufacturing the part. The project effort will include designing the rule base structure, generating the rule base by interviewing experts, defining the structure of the input data and the results of the diagnosis, implementing an inference engine, and test and demonstration of the system. As a feasibility demonstration, the project will be limited to the diagnosis of simple milling and lathe operations.

IMPORTANCE TO MANUFACTURING: The usual way of dealing with quality problems is to assemble a material review board (MRB) to diagnose the problem. The MRB function is critical to the future health of a system; without accurate results, the system will continue to create bad parts. The MRB function is also one of the most difficult functions to automate; it usually requires the interaction of several experts. A rule-based diagnosis system will provide a structure that can incrementally capture the required expertise and lead to an automated, reliable, and robust link between inspection and control.

FOR WORKSHOP USE
CODE # 16

CONTINUATION OF (project title) Rule-Based Process Diagnosis

POTENTIAL PAYOFF (quantitative, if possible): This project will achieve several goals. It will demonstrate feasibility of an AI approach to MRB functions. It will help define the role of part inspection in an automated manufacturing system. And it will contribute to defining data standards between inspection and control functions.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The major issue in applying rule-based diagnostics to manufacturing is that the processes involved in making a part interact. One process may remove evidence that another process was out of control. Also, several processes may contribute errors. Finally, an error may not be attributable to one process exclusively, but to the interaction between processes. These interactions require new inference mechanisms capable of diagnosing multiple faults.

PROJECT DURATION: 2.5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (times given are from start of project)

1) Design rule base structure: 6 months
2) Develop rule base; 8 months
3) Generate test data; 9 months
4) Implement inference engine for multiple-fault reasoning; 24 months
5) Build prototype system; 28 months
6) Feasibility demonstration; 30 months

RESOURCE REQUIREMENTS: 8.5 staff-years, $765K; AI Computer System, $30K.

PROJECT CLASSIFICATION (please check one):

XX Basic Research (long-term)   ___ Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

CODE # 17

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: AI Tools for Product Design for Economical Manufacture by Die Casting and Injection Molding -

PROBLEM DEFINITION/PROJECT OBJECTIVE: Productivity improvements are greatly influenced by the design of the products for ease of manufacture. Full advantage of any manufacturing process can be fully realized only when products have been designed to be manufactured most economically by the chosen process.

The objectives of this project then are to develop a series of AI tools for the design of products for economic manufacture, extending the methodology used in the UMASS work on "Computer-Aided Product Design for Economical Fabrication by Forging," to microcomputer oriented systems for injection molding and die casting.

PROJECT DESCRIPTION/APPROACH: What is required are systematic procedures, which embody this previous knowledge and experience, whereby designers may assess the manufacturing difficulty of a proposed part or product and subsequently determine the likely benefits or otherwise of design changes in terms of manufacturing costs. The product designer will want to know: if the part is produced by a given process will it be relatively difficult or not (preferably in terms of relative manufacturing costs); which features of the part lead to manufacturing difficulties and what will be the likely savings from eliminating such features; and what are the recommendations for detail design features of the part for ease of manufacture by the process?

IMPORTANCE TO MANUFACTURING: The objective is not to produce detailed cost estimating systems for individual parts but to indicate general relative costs so that the product designer may be guided to avoid features which are difficult to produce. The designer may then classify the component and the code number obtained will indicate qualitatively the relative manufacturing difficulty. This will be used to extract quantitative data with which the relative costs can be determined. The coding system indicates which component features are leading to the difficulties and the designer may then, by recoding the part, determine the relative improvement in manufacturing costs resulting from the elimination of these features.

FOR WORKSHOP USE
CODE # 17

CONTINUATION OF (project title) AI Tools for Product Design for Economical Manufacture by Die Casting and Injection Molding

POTENTIAL PAYOFF (quantitative, if possible): The ultimate benefit from this work will be the reduction in overall manufacturing costs by providing product designers with a ready means of assessing quantitatively the manufacturing difficulty of proposed part designs for specialized processes and determine the effects of design changes on manufacturing costs.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Plastic molding and die casting will be considered together because the same coding scheme and economic model can be used in both cases, but a different data base will be required for each process. This investigation will result in a data base of art and knowledge that can be used to design parts and products that are more economical to produce.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): 1)Data collection; 2) Formulation of classification systems which qualitively indicate manufacturing difficulty. 3) Simplified cost models of injection molding and die casting will be developed. 4) Data bases of material and shape dependent cost information and factors will be established. 5) These procedures will be converted to software for micro-computer systems for greater ease of use by product designers. AI tools will be arranged to suggest general design changes to the user in order to reduce costs and to give an indication of the approximate savings from these changes.

RESOURCE REQUIREMENTS: It is anticipated that the work would require approximately $ 125,000 per year and that three years would be required to complete the project. The funds would be used to provide both student and faculty support, to cover the necessary travel expenses related to the program and to provide the necessary support services.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

x Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 18

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES   x MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Artificial Intelligence Applied to Mechanical Design

PROBLEM DEFINITION/PROJECT OBJECTIVE:

The research described here has the long-term goal of improving the practice of mechanical design by developing theories and software tools for applying AI to the mechanical design and manufacturing process. This research program is an on-going collaboration . this research collaboration has as its objectives (1) to learn how to develop expert systems that can work in a CAD/CIM environment to do on-line evaluations of manufacturability of designs; (2) to learn how to use "design with features" as a method for creating design data bases that will serve manufacturing process planning as well as design and analysis needs; and (3) to develop a representation language tailored for expression of design knowledge that will serve the above two objectives, and thus facilitate the efficient construction of expert systems for mechanical design.

PROJECT DESCRIPTION/APPROACH:

The top-level strategy of our research program is to proceed from the specific to the general. That is, our plan is to develop working expert systems in specific domains selected so that we confront the research issues in each of the above areas in manageable steps. Then, with the understanding gained from these specific cases, we will generalize the new tools that are our ultimate objective. There are specific projects currently in progress as follows: (1) Development of an expert systems for plastic material selection; (2) Development of an expert system to select the optimum casting process for a proposed design; (3) Development of an expert system to design castings; (4) Development of an expert system to provide an interface to programs that perform mechanical analyses of castings; (5) Development of an expert system to produce a design of a manufacturable plastic extrusion from geometric and functional requirements input by the user; (6) Development of a program that can serve as an aid to the study of decomposition using the design of posts and beams as a case study; (7) Development of a trial program to perform domain independent redesign; (8) A study of how to represent and reason about quantitative methods of optimization. The work done to date in this research program has revealed and illuminated important issues requiring additional research and development before our goal of a new design language can be realized. These issues fall primarily into three major categories: redesign, decomposition of design problems, and representation of design geometry. The current research effort is addressing these issues, and the work proposed here will continue and expand these efforts, as well as initiating work on the new representation language.

IMPORTANCE TO MANUFACTURING: Our definition of "design" includes preparation of a plan for manufacturing. Thus design includes evaluation for manufacturability early in the design process. Specifically, we are learning how to use AI to incorporate knowledge into CAD systems so that manufacturability evaluation is done automatically as the design is created. We are also learning how to enable the design process to develop a single data base representation of the design that will serve manufacturing functions as well as designer needs. Finally, the language we ultimately expect to produce will facilitate development of expert systems including manufacturing considerations in the design process.

CODE # 18

CONTINUATION OF (project title) Artificial Intelligence Applied to Mechanical Design

POTENTIAL PAYOFF (quantitative, if possible): 1. CAD systems that aid manufacturability evaluations; 2. Improved design methodology with design-with-features; 3. Improved CAD data base that serve CIM; 4. A language that will facilitate development of expert systems and AI applications in design and manufacturing.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: 1. Knowledge and demonstration of how to develop expert systems within CAD environments. We plan to use injection molding as a specific example; 2. Test of concept of designing-with-feature as a design methodology, and as a method for providing a suitable single CIM data base. We plan to use casting as a specific example; 3. A new language for applying AI to design and manufacturing.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): 1. Completion of phase II of domain-independent redesign program (Dominic): 18 months. 2. Completion of phase I of decomposition program: 18 months. 3. Completion of data base/design-with-feature project: 36 months. 4. Completion of phase I of new language: 36 months.

RESOURCE REQUIREMENTS: At UNIV: $ 150,000 annually

At INDUS $ 150,000 annually

PROJECT CLASSIFICATION (please check one):

X Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

CODE * 19

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

_____ UNIT PROCESSES   __X__ MANUFACTURING SYSTEMS

_____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Object Oriented Design Tool

PROBLEM DEFINITION/PROJECT OBJECTIVE: Current efforts to construct systems which automatically generate an optimum manufacturing sequence for a specific part are hampered by the inability to automatically analyze a CAD generated part model in order to identify part features. Most current CAD systems represent a part as a combination of unrelated geometric structures such as, lines, circles, cylinders, surfaces, etc. that carry no inherent manufacturing data. This project would create a prototype CAD system which would automatically provide feature identification, in manufacturing terminology, as an inherent part of the CAD generated part model.

PROJECT DESCRIPTION/APPROACH: The project would consist of two simultaneous efforts. The first would involve the construction, in a LISP processor, of an object oriented 3-D CAD system which would utilize a library of shapes which could be modified and assembled to form a complete part model. Each shape in the library would graphically represent the result of a specific type of manufacturing operation and would be part of a program "object" which would contain additional manufacturing information. Object contents would include the maximum and minimum geometric limits of a shape as specified for its operation type by a manufacturing expert.
The second effort would develop the mechanism by which the program structures (objects), would represent the geometric limits of each shape provided in the system library and restrict any modification of the shape to those limits.

IMPORTANCE TO MANUFACTURING: Object oriented CAD provides a means of creating a part design which carries with it all the data required for identification of the methods to be used in its manufacture. Because the system uses graphic objects which cannot be modified beyond limits defined by manufacturing, it would insure that most designs derived with it are producible.

CODE 19

CONTINUATION OF (project title) *Object Oriented Design Tool*

POTENTIAL PAYOFF: The most significant savings would occur as a result of eliminating the most difficult portion of the analysis required to automatically determine how the part is to be manufactured. An additional system can be made, using current technology, which would perform the remainder of this analysis automatically and produce a complete process plan for the part. (see Generative Process Planning for Manufacturing CODE* 5). This type of design tool would also eliminate most of the cost of rework and redesign resulting from manufacturing limitations discovered on the shop floor because they were not accounted for in the original part design. In addition this system could automatically produce a very complete part classification code as a byproduct of the design process.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This project would solve the problem of how to automatically recognize part features in a CAD system in order to initiate automated process planning.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): 1) define system abilities, application area and object representation methodology 1/4 yr. 2) create basic operating structure of bit mapped 3-D display system 1 yr. 3) provide enough graphic manipulation capability to result in a usable 3-D CAD tool 2 yr. 4) create basic control mechanism to limit graphic manipulation 1/2 yr. 5) provide scheme for explicit knowledge representation in program objects 1/2 yr. 6) provide working example of design tool library 1 yr.

RESOURCE REQUIREMENTS: 2 LISP machines ($120,000), 12 manyears
2 grad students full time 3 years graphics development
2 grad students full time 2 1/2 years program development
1 Mfg. Engr./Process Planner/Machinist part time 1/2 yr
1 Sr. Researcher part time for duration

PROJECT CLASSIFICATION (please check one):
____ Basic Research (long-term) ____ Exploratory Development (mid-term)
_X_ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 20

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES X MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: MANUFACTURING EXPERT PLANNING SYSTEM

PROBLEM DEFINITION/PROJECT OBJECTIVE: The generation of Classification and Coding (CC) and process plans for aircraft parts is presently a costly and labor intensive task. This task has necessitated the services of experienced planners and engineering liaison personnel. Frequently as these experienced planners retire or leave their jobs for some other reasons it becomes very hard to replace them. The objective of this project is to automatically generate the CC and process plans by incorporating artificial intelligence (AI) technology.

PROJECT DESCRIPTION/APPROACH: A substantial amount of the information needed to generate CC can be directly derived from a digital representation (shape and non-shape data) of the engineering model. The remaining information needed consists of decisions to be made based on expertise of the process planner and the availability of manufacturing resources. An expert system will be developed to capture the planner's expertise and manufacturing practices for use, first in the generation of Classification and Coding, and second to implement a generative process planning system. The system will be developed to handle sheet metal, machined and composite parts.

IMPORTANCE TO MANUFACTURING: The expert system will be used to accumulate expertise, judgemental knowledge and heuristics of process planners with many years of experience. The system will be flexible enough to allow modification in the event of changes to manufacturing practices. It can be used for training new planners. It would provide an integrated approach to CAD and CAM. The system would contribute significantly toward the reduction of paper bound manuals and instructions thereby further reducing the probability for error. The system would reduce maintenance of huge databases for variant process plans.

FOR WORKSHOP USE
CODE # 20

CONTINUATION OF (project title) MANUFACTURING EXPERT PLANNING SYSTEM

POTENTIAL PAYOFF (quantitative, if possible): Reduction in manpower currently involved in Process Planning and Work Order Release operations. Improved quality and consistency of Process Plans. Allow for optimum Process Plans. Provides a link between CAD and CAM toward Computer Integrated Manufacturing. Enhances Group Technology concepts.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This project will aid in the advancement of the state-of-the-art technology in Process Planning and significantly contribute to automation of planning and sequencing operations.

PROJECT DURATION: 3 **CALENDAR YEARS**

MAJOR MILESTONES (include timeframe):

Prepare a Development Plan - i/2 years

Develop a Prototype System - 1-1/2 years

Develop, evalute and integrate System - 3 years

RESOURCE REQUIREMENTS:

30 Man Years

VAX 11/780, Symbolics 3670

Expert System development tool

PROJECT CLASSIFICATION (please check one):

____ **Basic Research (long-term)**   X **Exploratory Development (mid-term)**

____ **Manufacturing Technology or Advanced Development (near-term)**

SESSION #: 3

AI/WORKSHOP EVALUATION
July 31, August 1, 1985
GROUP: 2

	CRITERIA	1	2	3	4	5	6
PROJECT #: 1	MEAN	6.71	4.82	5.14	3.39	3.93	4.07
	ST. DEV.	1.46	1.39	1.53	1.31	.90	1.12
PROJECT #: 2	MEAN	5.39	7.39	6.75	6.50	6.18	5.21
	ST. DEV.	1.85	1.47	1.73	1.77	1.59	1.34
PROJECT #: 3	MEAN	4.32	6.68	6.39	4.14	5.93	6.50
	ST. DEV.	1.79	1.28	1.40	1.86	1.21	1.97
PROJECT #: 4	MEAN	4.96	7.25	7.00	5.57	4.64	4.61
	ST. DEV.	2.12	1.67	1.25	1.60	1.25	1.31
PROJECT #: 5	MEAN	6.21	7.39	7.21	6.54	6.36	5.86
	ST. DEV.	1.95	1.66	1.83	1.84	1.45	1.53
PROJECT #: 6	MEAN	4.46	6.29	5.86	5.79	3.46	3.36
	ST. DEV.	2.10	1.80	1.65	1.47	1.32	1.28
PROJECT #: 7	MEAN	5.54	6.36	5.75	5.68	4.11	4.39
	ST. DEV.	1.90	1.25	1.29	1.70	1.17	.92
PROJECT #: 8	MEAN	5.18	5.50	5.46	3.79	5.07	5.18
	ST. DEV.	2.09	1.75	1.79	1.79	1.30	1.52
PROJECT #: 9	MEAN	5.39	6.04	5.86	6.39	3.82	4.54
	ST. DEV.	1.91	2.01	2.03	1.47	1.19	1.20
PROJECT #: 10	MEAN	6.00	6.64	6.64	5.43	5.11	5.00
	ST. DEV.	1.89	1.16	1.06	1.37	.96	1.09
PROJECT #: 11	MEAN	4.11	5.96	5.96	5.46	3.68	3.54
	ST. DEV.	1.99	2.08	2.01	2.17	1.54	1.50
PROJECT #: 12	MEAN	5.11	6.36	6.25	5.46	4.89	4.68
	ST. DEV.	1.81	1.59	1.51	1.50	1.26	1.56
PROJECT #: 13	MEAN	5.89	6.54	6.32	4.46	5.46	6.29
	ST. DEV.	1.62	1.00	.98	1.55	.74	1.21
PROJECT #: 14	MEAN	4.64	5.68	5.93	5.43	4.61	4.57
	ST. DEV.	1.47	1.54	1.61	1.43	1.03	1.26
PROJECT #: 15	MEAN	4.79	4.64	4.68	4.32	5.46	5.39
	ST. DEV.	1.87	1.54	1.47	1.54	1.26	1.23

SESSION #: 3

AI/WORKSHOP EVALUATION
July 31, August 1, 1985
GROUP: 2

	CRITERIA	1	2	3	4	5	6
PROJECT #: 16	MEAN	6.36	7.64	7.21	6.54	4.36	4.82
	ST. DEV.	1.50	1.10	1.42	1.48	.91	1.25
PROJECT #: 17	MEAN	6.25	6.68	6.50	5.50	5.21	4.71
	ST. DEV.	1.08	.98	1.07	1.37	.74	.90
PROJECT #: 18	MEAN	6.21	7.46	7.29	6.57	3.96	3.68
	ST. DEV.	1.20	1.20	1.08	1.32	1.10	1.28
PROJECT #: 19	MEAN	6.46	7.14	6.71	6.54	4.32	4.43
	ST. DEV.	1.35	1.48	1.24	1.71	.94	.92
PROJECT #: 20	MEAN	5.71	6.82	6.57	5.82	4.57	5.82
	ST. DEV.	1.58	1.28	1.32	1.68	1.20	1.61

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 2

PROJECT # 1

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	2	0	4	1	13	7	1
2:	0	0	7	5	4	11	0	1	0
3:	0	0	7	1	8	6	5	1	0
4:	2	6	7	5	8	0	0	0	0
5:	0	0	12	6	10	0	0	0	0
6:	2	0	4	10	12	0	0	0	0

PROJECT # 2

CRIT. #	1	2	3	4	5	6	7	8	9
1:	2	0	1	6	3	7	8	0	1
2:	0	1	0	0	0	5	7	9	6
3:	1	0	0	1	4	4	6	10	2
4:	0	1	1	1	5	4	7	6	3
5:	0	1	1	0	9	2	10	4	1
6:	0	1	1	6	10	3	7	0	0

PROJECT # 3

CRIT. #	1	2	3	4	5	6	7	8	9
1:	2	3	5	4	4	8	2	0	0
2:	0	0	0	0	7	5	8	6	2
3:	0	0	2	0	5	5	10	6	0
4:	3	1	8	3	7	4	0	2	0
5:	0	0	1	0	12	4	10	0	1
6:	0	1	2	0	7	3	3	8	4

PROJECT # 4

CRIT. #	1	2	3	4	5	6	7	8	9
1:	3	1	3	4	4	3	[illegible]	1	0
2:	1	0	0	1	0	2	12	6	6
3:	0	0	1	0	3	1	13	9	1
4:	0	1	2	4	6	5	9	0	1
5:	1	0	4	5	12	5	1	0	0
6:	0	1	5	6	11	3	1	1	0

PROJECT # 5

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	2	2	2	2	2	11	6	1
2:	0	0	1	1	2	3	5	7	9
3:	1	0	0	2	0	3	8	7	7
4:	1	1	1	0	1	5	11	7	1
5:	0	1	0	0	7	5	11	2	2
6:	0	1	1	0	12	3	9	0	2

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 2

PROJECT # 6

CRIT. #	1	2	3	4	5	6	7	8	9
1:	2	2	7	4	5	3	2	2	1
2:	1	0	2	0	5	4	9	6	1
3:	1	0	1	2	7	6	8	2	1
4:	0	0	2	4	6	5	8	3	0
5:	2	4	10	4	7	1	0	0	0
6:	2	5	10	3	8	0	0	0	0

PROJECT # 7

CRIT. #	1	2	3	4	5	6	7	8	9
1:	2	1	1	3	3	5	13	0	0
2:	0	0	0	1	9	3	9	6	0
3:	0	0	1	5	6	4	12	0	0
4:	1	0	2	3	6	4	11	0	1
5:	1	0	8	7	11	0	1	0	0
6:	0	1	5	4	18	0	0	0	0

PROJECT # 8

CRIT. #	1	2	3	4	5	6	7	8	9
1:	3	0	3	4	4	2	11	1	0
2:	2	0	0	3	10	4	6	3	0
3:	2	0	0	5	6	7	6	1	1
4:	4	3	5	4	10	0	1	1	0
5:	0	0	3	4	15	2	3	0	1
6:	0	0	4	4	11	5	1	2	1

PROJECT # 9

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	1	1	8	4	1	10	1	1
2:	1	0	1	5	5	2	7	4	3
3:	1	1	1	5	4	1	9	5	1
4:	0	0	1	1	8	1	12	3	2
5:	0	5	7	4	12	0	0	0	0
6:	0	0	6	7	12	1	1	1	0

PROJECT # 10

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	2	1	3	6	0	9	7	0
2:	0	0	0	0	7	4	9	8	0
3:	0	0	0	0	5	7	9	7	0
4:	0	1	1	4	9	6	6	1	0
5:	0	0	0	8	12	5	3	0	0
6:	0	0	1	9	11	3	4	0	0

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 2

PROJECT # 11

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	6	7	3	2	6	1	2	Ø
2:	2	1	1	1	2	8	7	5	1
3:	2	1	Ø	1	5	5	9	4	1
4:	2	2	1	3	3	7	7	1	2
5:	2	6	5	3	11	Ø	1	Ø	Ø
6:	2	6	7	3	9	Ø	1	Ø	Ø

PROJECT # 12

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	2	1	6	6	6	3	3	Ø
2:	Ø	1	Ø	1	9	1	7	9	Ø
3:	Ø	1	Ø	Ø	1Ø	4	5	8	Ø
4:	Ø	1	1	5	9	3	7	2	Ø
5:	1	Ø	3	2	15	5	2	Ø	Ø
6:	2	Ø	3	3	16	2	1	Ø	1

PROJECT # 13

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	Ø	1	3	6	1	15	1	Ø
2:	Ø	Ø	Ø	Ø	7	2	16	3	Ø
3:	Ø	Ø	Ø	Ø	8	5	13	2	Ø
4:	1	1	8	1	1Ø	6	Ø	1	Ø
5:	Ø	Ø	Ø	Ø	19	5	4	Ø	Ø
6:	Ø	Ø	Ø	Ø	1Ø	5	1Ø	1	2

PROJECT # 14

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	2	5	5	8	6	1	1	Ø
2:	Ø	Ø	4	1	9	2	1Ø	2	Ø
3:	Ø	Ø	2	2	1Ø	3	5	5	1
4:	Ø	Ø	3	5	7	3	1Ø	Ø	Ø
5:	Ø	Ø	6	3	16	2	1	Ø	Ø
6:	Ø	1	6	4	12	3	2	Ø	Ø

PROJECT # 15

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	1	8	2	5	4	6	1	Ø
2:	1	Ø	7	4	8	4	4	Ø	Ø
3:	1	1	4	4	11	4	3	Ø	Ø
4:	1	1	1Ø	1	7	7	1	Ø	Ø
5:	Ø	Ø	1	2	17	2	4	1	1
6:	Ø	Ø	1	4	15	Ø	7	1	Ø

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 2

PROJECT # 16

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	1	1	0	4	7	10	4	1
2:	0	0	0	0	1	3	8	9	7
3:	0	0	0	1	2	7	4	8	6
4:	0	0	2	0	5	3	11	6	1
5:	0	0	7	5	15	1	0	0	0
6:	0	0	4	5	15	2	1	0	1

PROJECT # 17

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	0	0	10	4	11	3	0
2:	0	0	0	1	3	4	16	4	0
3:	0	0	0	2	3	5	15	3	0
4:	0	1	1	4	8	5	9	0	0
5:	0	0	0	2	21	2	3	0	0
6:	0	0	3	6	16	2	1	0	0

PROJECT # 18

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	0	1	10	3	10	4	0
2:	0	0	0	1	1	2	9	10	5
3:	0	0	0	0	2	3	12	7	4
4:	0	0	0	1	8	2	8	9	0
5:	0	4	5	7	12	0	0	0	0
6:	1	5	6	7	8	1	0	0	0

PROJECT # 19

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	0	2	5	8	5	7	1
2:	0	1	0	0	1	4	13	3	6
3:	0	0	0	1	5	4	10	7	1
4:	0	1	2	0	3	4	9	8	1
5:	0	0	7	7	12	2	0	0	0
6:	0	0	4	12	8	4	0	0	0

PROJECT # 20

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	1	2	4	3	7	9	2	0
2:	0	0	1	0	4	2	13	7	1
3:	0	0	1	0	6	4	9	8	0
4:	1	0	1	4	4	6	10	1	1
5:	0	2	3	5	15	1	2	0	0
6:	0	0	2	2	11	3	7	0	3

MANUFACTURING SYSTEMS RECONCILIATION COMMENTS

Project 1

The study of material handling is ideally suited to simulation technique when parameters relating to specific part families, inventory handling, procedure, customer order characteristics, etc. are nicely handled by queing techniques.

Problem is not understood; over simplification as to what is needed. I don't believe the approach, as stated, makes any contribution to understanding of AI techniques or applications.
Resource is way too low to solve real problem behind material management selection. It is part of larger system design problem.

0.1 M:Y for the "expert" seems to be too short.

This seems to be a standard ES application. It could be easily implemented on a P.C. and wouldn't contribute any significant new knowledge to the field.

Feasibility - project is quite doable

Much material handling equipment is often times improperly selected because of the lack of information available to the decision maker.

The Material Handling Center at Georgia Institute of Technology should serve as a source of experts for some years to come. In general, if a center of expertise exists is an expert system needed? If so, shouldn't they be the ones who develop it?

Utility to manufacturing rated low due to situation specific nature. It appears common consensus that this is not valuable to pursue. (Note: It is interesting that in original ICAM roadmaps "material flow" never found support either.)

Might include an example of the rule type to be generated.

Material handling specifications are a natural for conventional simulation techniques. The problem to be addressed is how to keep inventory moving through a facility to avoid both bottlenecks and large static buffers. The emphasis should be placed on identifying the parameters needed to solve the problem.

It is doable without question. Ed Fisher at NC State currently has a prototype running.

Could be a transportation simulation system (rail, ship, truck, least cost, most efficient, etc.) that uses AI tools for user interface (like the project which would use AI tools to interface with other OR systems).

Project 2

The objective and approach says absolutely nothing! The design of a real-time control system for cell-level manufacturing, I believe, has major payback. I feel that more resources should be devoted to project.

I feel to accomplish the project objective will require development of learning capability which is a definite contribution to AI.

C1: NBS & TI are currently pursuing it.
C4: Exception handling involves context dependent diagnosis and planning integrated together in a near real-time environment. No work has been completed so the issue of architecture is an unanswered question.

Much of the software required has already been developed (will be shown at upcoming IJCAI in LA.).

C1: Approach is ill-defined, how augmented?
C4: Rule based controllers are in production use, nothing new.

The approach and milestones do not give a picture of what will be done. There are lots of buzz words, not much substance.

As a basic research proposal, there is no statement as to "new" idea being pursued. There exist real-time ES systems today for non-manufacturing applications. Should state why these won't work.

In our FMS environment, the exception handling capability is a significant cost driver. This is not basic research, it is advance development and the project should take only 3 years.

Real-time control is now non-existent (virtually) in manufacturing. Basic research is extremely important in this area.

There are many kinds of cells. Is the control system cell-specific, or can a generic control system be developed?

Tremendous controversy between those who think problem is solved and those seeing research requirements. No consensus.

Control important issue, proposal not good.

Might include example of type of rule to be generated.

For this and the other scheduling projects (Projects 4 & 12) my comments are the same: The system must interface to the shop floor equipment in a real-time manner through the use of sensors and status feedback to the cell. Emphasis needs to be placed on the parameters needed to make decisions. Also, the scheduling problem should be decomposed into sub-goals to allow the shop to perform at one level, the cells at a second level, and the work stations at a third level. We don't need optimal scheduling. What we need is a schedule that is feasible at time T. The schedule can be changed based on the environment at $T+\Delta T$.

Texas A&M University is under contract to produce a proof of concept prototype by Christmas which controls an operating FMS for a large Texas based company.
The issue of AI based control for due-date driven systems has never been addressed for large or small systems and what architectures are appropriate is an open issue.

Project 3

This system would require total integration and re-structuring at the manufacturing system of a user company. Nobody would take the financial risk in a large organization at implementing this.

Problem is not understood by the proposer. This may be a case of solving the symptoms without understanding the disease - nothing to do with AI.

C4: This seems like a standard system to me. I don't see the AI content. It's hard, but it's not AI.

10 people working for 5 years seems unreasonable for a non-basic research project.

C4: I do not believe this is an AI/ES application. Technology exists or is easily developed today which promotes configuration management through the manufacturing process. Such technology is found in or may be easily added to system modules commonly found in MRPII type systems. Additionally, it may be found in certain CAD/CAM systems. Perhaps a program to integrate this technology is a better idea.

C4: Feel data base management technology could solve problem...don't see AI impact.

I have not changed C2, C5, and C6 since there is a very major problem in aircraft manufacturing and to do it is grossly underestimated. Have seen production write as many as 20 engineering changes stapled to engineering drawings when only 2 is max allowed.

No approach of any significance given as to how project would be accomplished.

For this project to be integrated with the shop floor control and manufacturing data base systems will be a significant contribution to the S and T base.

Not enough detail - 50 my for whom???

There are many good automated engineering change management systems. The problem does not require AI but requires a good data base facility.

C6: 50 man years looks high.

I believe this task can be better handled using conventional approaches rather than AI techniques.

Importance is obvious, but problem very large and infra structure of corporation will create difficulties. Don't miss impact on scheduling here.

Important problem - should identify the real cause of problem and create a technology answer to it.

C4: The project, as described, is not an AI problem. With the addition of the abilities to manage the implications of change and/or to make decisions on the best approach to the application of change, I would support the project. As written it is just a data management problem.

The project should be considered a problem of data base management., It is important to understand the data requirements of the systems that interface to an EC system and make sure that the preparation is available at all times. We need to pay special attention to tying the materials information into the design data base and into the production scheduling system.

Traceability is an advantage to be sought from an engineering change management system. It's needed for a failure analyses, evidence for product liability litigation and insurance, and feedback to designers.

This project should be re-written to propose the construction of a generic tool which would allow users to easily construct a model of their existing change management system. The model, with or without an attached expert system could provide the visibility needed to determine the impact of a proposed change. It's not practical for us to fund development of a system which, in order to be used, would require replacement or major reconfiguration of large portions of our existing manufacturing organization.

Although applications of AI can profitably be made in this are, the project as described here is not an AI project.

It does seem to be a data base management problem; possibly AI can help. The integration will be an advancement in the SOA.

This is not an AI system; what is suggested does not advance the scientific or industrial base.

As worded, probably not an AI application, but could be if expanded to include the impact of ECO's on systems.

Too little detail - shows a guess, not an estimate.

Project 4

C1: does not describe an approach - create a KBS says something.
C5: problem is complex!!!!!

3 people for 3.5 years seems practical to deliver a new piece of software.

C4: much of this technology already exists. In what way does this project propose to be something different than that which exists.?

C3: Shop floor scheduling has huge payoffs, as outlined in program description.

This project is only feasible as is stated in the descriptions if a manufacturing information data base system exists of high integrity and accuracy - to my knowledge, in aerospace, they really don't exist.

The approach described is process specific; I don't believe the result will have general applicability.

The approach says absolutely nothing. Emphasis needs to be placed on developing the constraints and parameters used in scheduling. A good scheduling system will need to integrate with the control operations on the shop floor.

A basic assumption is wrong. There are hundreds of projects on scheduling and thousands of papers. What reason is there to expect that AI will make a difference.

I do not believe it feasible to devise an intelligent schedule by putting rules into a standard expert system shell. Different techniques will be required. Furthermore, even if the problem could be solved using a standard expert system shell, this would constitute no significant scientific advance. It would simply be an application of existing technology to a new area.

The write-up neglects the importance of understanding the relationships in the manufacturing systems under study. Not as straight forward as presented.

Much too broad a problem statement. Recommend attack project #6 first to set stage.

The scheduling problems are important, but represent heavily plowed ground. I would like to see more evidence that AI will help or be useful in this area. The approach and milestones should therefore be more clearly stated.

Twenty-five percent of the projects were on scheduling.

Suggest you get a copy of the white paper on the subject from Prof. Wm. Maxwell, College of Engineering, Cornell University, before proceeding in this area.

I have reservations about the use of the term "expert system" in the project description. I think AI techniques, in general, are useful here, but expert systems techniques are too limited to be of major use. If "expert system" were replaced by "AI system", then I would change C1 from 3 to 6 or 7.

I just do not see how the proposed system would be "more efficient". I think there may be applications for AI in shop scheduling, but the subject needs much more thought and discussion.

One can make a contribution to this area without reorganizing General Motors, i.e., the author's estimates in C5 and C6 are reasonable.

Project 5

C1: The author states in milestones "Determine how to analyze CAD data to generate knowledge" - this is a difficult problem in its own right and shouldn't be mixed into a generative planner.

If the project were intended as exploratory development or advanced development, I would agree with the assessment, but I don't think a "basic research" project would require that much time.

I strongly feel that the project is feasible since processes are known today except they reside within the experience of the process planner. If design information can be passed from engineering to manufacturing in terms of features, tolerances, and specifications, it is possible to combine this information with a rule based system to create process plans.

Generative process planning should be addressed in exploratory range. Other efforts are already generating results and potential near-term benefits. This statement is so general that it would not contribute to knowledge of an expert in the area and would not advance payoff a significant increment.

The project is too far-out and too general.

I have revised C5 and C6 but only on the basis a 3-D solid geometric CAD system that is a real-time system, is available for design and detailing and dimensioning.

C6: no change - not enough detail to evaluate - 50 my for whom?

To accomplish objective will result in significant step in feature recognition and thus contribution to AI.

This project is so global, so poorly defined, that it has no value in its present form.

Approach is not clear. If it's not feasible it's not important and has no payoff. 10 cy and 50 my also make me question feasibility.

The response does not address the issue of importance to manufacturing.

Not easy. Secret is to segregate process requirements from equipment capabilities. Then generic approach is feasible.

While much work is being done in this area, it is sufficiently complicated to warrant closer study. Generative process planning is a fertile area for research and development.

I think the scope is too wide. Specifically, feature extraction should be a separate project.

Would like to see project separated into more definable parts.

Important problem - I feel it is part of unit process activity.

Scope needs redefining - must carve out the basic research, not "the whole enchalada".
Not enough detail in resource estimate.

A lot of projects are in progress already on computer-aided process planning. A clearer, more comprehensive write-up is needed.

Experience in building this type of system has taught us that generative planning software flexible enough to apply to a broad range of manufacturing environments would be so unstructured that it would be practically indistinguishable from commercial AI development software currently available or soon to be introduced.

Needs to be split and made more specific. Apparently applies only to fabrication and should say so.

Still too general and global to be accomplished.
Time and resource estimates are too low for such a difficult project.

Project 6

We do not know how to create a very good scheduler for a specific environment let alone a general scheduler building system. Smacks of automatic programming.

Not clear what is being proposed. No clear, real manufacturing problem in mind.

An efficient tool of this type is essential and it does not exist today.

I think the ability to schedule with an ES is very important and has good payback in today's complex shop floor decision environment.

I feel that a good software system that can represent the factory and its capabilities is extremely important and has a big payoff. Such a system helps in defining the design of a factory and understanding the interface problems when systems are integrated.

Commercially available systems (i.e. KEE) will/should decrease difficulty/increase feasibility.

There are already many many projects in progress on system scheduling. The approach described does not generate confidence of success.

I don't believe this is a feasible project, given the timeframe or resources.

It's important. This should be combined with #15 and #9 under category of knowledge-based systems designs aids for developers.

Good project with good insight. Pursue aggressively.

To be used as a consulting tool? For what other purpose? Sounds like a tailorable MRPII system.

Problem important. I feel approach is wrong. Need understanding of context or
Still the payoff & contribution is very high when you apply AI//es to specific areas.

Project 7

C1: The FMS design cycle is incorrect and contrary to the problem statement. Simulation is highly successful as a design tool. Also, design criteria are dependent upon management policy, so no "generic" criteria readily exists.
C4: The system cannot optimize as stated since the criteria for acceptability is a management policy decision which is highly situation dependent.

C1: 2 This project would attempt the automatic re-configuration at a plant cell layout to optimize output. Establishing the rule base to treat an individual situation would take far longer than arriving at an optimization manually if the simulation allowed easy manual alteration. Such a simulation has already been built with a simulation tool which will be displayed at IJCAI in LA.

FMS development is not to the point where this potential level of inference can be obtained. Not sure because of its complexity that it would be worthwhile, even if the proposed work could be done. Believe this is more of a "blue sky" effort.

Simulation interfaced with expert systems seems to invoke something that doesn't mix real well. Simulation will be the expert? If so, needs to be readdressed.

Poorly worded with debateable integration of simulation and ES.

No clear statement of technical objective or approach.

A lukewarm response due to other projects of greater importance.

FMS design assistance is absolutely needed.

If contribution to science is higher than 3, should be able to see the next and subsequent steps. I cannot.

Role of simulators and expert systems important. Possible topics:

1. ES to aid building and evaluating simulations
2. Simulators as a form of expertise.
3. ES to guide simulators: Turn simulators into "prescriptive tool" from being a "descriptive" tool.

Simulation systems are shipped as part of the product when FMS's are shipped. Suggest John Hughes of Kearny and Trecker Co., Milwaukee, as a source of information on the subject.

I stand by my opinion that this is an ill-conceived and impossible project because FMS system design is not performed in this manner. It ignores the use of analytical models designers use to select configurations (e.g. Purdue's CAN-Q) prior to simulating for detail design information.

This project probably not feasible because it proposes automatic re-configuration of the simulation.

Project 8

C2 & C3: Training will be a very important component in properly operating these upcoming, complicated and non-physically visible (i.e. computer) systems. If the training system is done right, there should be much better operation of the systems.

We experimented with teaching machines in the 60's with disasterous results. This project is not desirable because of lack of assessment of social/psychological effects.

Are they talking about an expert system for training or training on an expert system?

This is business gaming not AI!

I feel that the project is totally ill-defined. The training can be better accomplished using simulation tools.

C1: doesn't provide an approach.
C4: training is a significant problem in some organizations.
C5 & C6: underestimates size of project in order to build good interfaces.

Contribution to science would be in the area of training, not manufacturing. The payoff would be questionable there.

This approach was tried with Mycin and didn't work (Clancey). If you just want to run sample cases and let a trainer see results and a list of rules that failed, this is trivial. True intelligent tutoring systems are among the most difficult of all AI problems.

Excellent problem area. Proposer has not identified resource to acquire training knowledge.

C1: 8 This project is very feasible. We intend to implement one of our expert systems within 6.9 months and are already certain it can be used as a training aid.

Training tool development seems to me to add little to nothing to the science and technology base.

Mediocre impact potential compared to other projects.

Intelligent tutoring is very, very difficult. HONEST!

Suggest that training assistance is important and needed, but much more work needs to be done in learning how the mind learns before applying AI techniques to that task. With as many "educators" present in the workshop as there were, I though some good discussion of this project would be forthcoming.

Is it an expert system for training or vice-versa?

The importance of training not covered in discussion. It may be one of the most important near-term applications of knowledge based systems.

Eminently feasible - in fact, this capability is a "textbook" advantage of expert systems in general, often cited.

I think the project is tomorrow in scope. If it is just to help in shop-floor scheduling then simulation tools are better. However, I feel that expert systems to instruct staff in many aspects of manufacturing, inspection, NC programming, process planning, etc. would be very useful.

I see some merit in this from an educational standpoint. Who should support it?

Contribution to science low - if any, it relates to training technology and manufacturing.

Project 9

Approach is not clear as to what will be done, or how. Six MY is too much for an exploratory project.

I think that it is absurd to combine AI and OR directly. An option for determining when it is more efficient to use one methodology over the other based on the problem domain would be useful.

OR tools can solve problems; however, the problem with OR is its accessability to the engineer confronted with the problem. This project would use AI to make these tools accessible and thereby open up a large problem solving paradigm to manufacturing.

Too broad, too much against the current areas of AI and OR expertise. The OR techniques cannot talk to the shop floor variabilities that the ES can. They should communicate but not be integrated.

Too abstract to determine importance or payoff - statements do not get to the bottom line, only abstractions to the people in the research area.

Description of "approach" is really another statement of objectives. No approach given.

From planning the integration of our simulation program and our expert system for our own FMS, I found the estimate to be very high.

This is my original assessment, which only became an outliner on this last round. The payoff in fusing AI/OR is high because it provides capabilities from the "best of both worlds" (symbolic, qualitative, inferential)/(quantitative, concrete, well-understood). The AI planner/analyzer must have some grist for its mill.

Tie to project #6 as thrust for tools to support such areas as scheduling.

Good application for AI tools.

Would like to encourage work along these lines.

Future payoffs greatest where multiple computer approaches may be brought together into single system.

Tremendous benefits could be realized in systems development area (ref. Intellicorp's push to develop SIMKIT)...Both cost reduction and avoidance would help make better systems design decisions the first time. IMPORTANT!

To reiterate, AI will provide access to these tools for an engineer both to help in tool selection and to help in model formulation, execution and result interpretation.

Project 10

A lot of this kind of work has already been done. Is this really AI? If so, what will be done?

C3: I don't know where the sensory information about impending failures will come from. Sophisticated multi-sensory inspection techniques are difficult issues, but assumed here. The ES may not have many symptoms for its data base.

The project is incomplete. It must also analyze sensor data to take appropriate action. The problem is better suited to conventional techniques other than AI.

I believe this belongs in the unit process group.

C1 & C2: This system is absolutely necessary for successful automation of complex systems.

I still wonder how easy it is to "detect" failure across a broad range of applications. This capability is the starting point of the project. Can we monitor the machine only, or must we inspect the output of the machine - part inspection, a highly difficult proposition.

Good project. Important but belongs under preview of unit processes.

Building an AI system using inputs from adaptively-controlled machines and "expert" reasons is a really good idea, but I'm not sure that this isn't a basic research issue.

Very good proposal.

Is this really AI? Consider combining with Project 16.

Project 11

This is short term. Integrated programming is the proper approach.

I disagree that the payoff and importance to manufacturing can be gleaned directly (e.g. MT) from this approach but I will agree that this could be exploratory development in nature.

In shop floor scheduling, most of the companies face resource constraints and goal of schedule would be to optimize those resources. That is very important to a company's survival and profitability. This may be the most important project of all! This AI system would solve many problems I have faced while developing 3 different scheduling systems in 3 different manufacturing environments.

Approach is not well worded but concept (the same as others in the scheduling ES) is sound.

Project description is vague throughout.

C1 & C3: very important problem.
C5 & C6: underestimates difficulty of problem.

I don't think it is feasible to construct a good shop floor scheduler by looking at how to schedule courses. I doubt the problems are similar enough if the goal is to produce something to be used on the factory floor.

C1: the approach, as stated, is to solve a different problem unrelated to manufacturing under the false assumption it is analogous.

C4: similar to project #4, C4. Scheduling improvements have large payoff potential.

Approach is not clear - simplistic!

Still more scheduling "research". Approach is not specific therefore, importance and feasibility are both rated low.

No objective is stated.

This project proposed does not understand the problem of the shop floor in a major aerospace company with hundreds of shop orders - MRB's, etc., floating through the system.

Lesser potential than Projects 4 or 6 and I question transportability of result from academic scheduling to job shop.

Scheduling topic important. Don't see an objective here.

Not a real clear proposal; sounds like resource/facility usage optimization. AI tools used as interface to existing OR techniques might work OK.

Without having had an opportunity to discuss this, I see no reason to change my viewpoint. As I said the last time, I don't think a system designed to do course scheduling in an university will be of direct use on a shop floor.

Typical scheduling with resource constraints - very feasible but site-specific.

Project 12

C1: We intend to do this within the next 3 years.

C5 & C6: Finally some detail in the time and resource estimate and it is very reasonable.

Response does not address the issue.

No statement of objective. What is given does not make any sense.

C2: The project described (objective) is to specify a manufacturing system based on cellular manufacturing. This is easy to do with rotational symetrical parts but not double creased sheet metal parts (i.e. aircraft structure) thus, in aerospace it will not cover many of the manufacturing parts - also project is grossly underestimated in time and resources.

Lesser potential than Project 6 but approach stated more clearly. Would merge with 4, 6, 9, and 11 to create CIM research thrust.

Better project definition required, other than that, a good proposal.

I'm just not sure this is a well thought-out idea. What about changing the proposal so that it attends to project management issues (task identification, estimating, resource allocation, etc.).

Project 13

This project is an implementation of existing concepts. There is no additional contribution for the advancement of technology.

AI is not necessary for this project.

C4: basic research on purchasing data bases?? What science or technology advance?

1) Purchasing/procurement functions are well understood, 2) many of the decision support elements required may already exist.

Vague approach.

Design of experiments is an excellent application area for capturing existing layman knowledge.

C4: much attention has historically been given to procuring parts in one's own shop; little at all has been given to efficiently procuring from outside sources. While vendor selection performance evaluation, and purchase activity optimization has been done to some degree, no attempt to my knowledge, has been made to intelligently treat vendors as resources which need to be evaluated, selected, managed, and controlled.

In our (defense electronics) business area, this is a tremendous problem - judicious selection of materials can have many benefits well downstream of purchasing activity!

Possibly the greatest payback to manufacturing lies with this family of projects for material strategic and tactical planning. Another thrust appropriate here.

Not basic research as described. Construction would be to place purchasing in the global, strategic problem of material management.

Good problem - experts exist. Activities possible in all 3 categories (research - MANTECH).

It's not clear how or whether AI would help.

I really think this system has merit, especially when the "global" aspects of outside procurement are considered. Remember, too, our factories are moving rapidly towards increased outside sourcing.

Project 14

It is important to close the loop from field experience (or simulations of) to manufacturing designers.

This project seems to be more of an engineering program than a manufacturing program.

C1: I think this is feasible only as a research project or if it is applied in electronics or some other field where design parameters are well known and controlled. Structural design is still too unstructured a field to allow success for this type of project.

I don't see any clear statement of how expert systems are to used for this task. It's not clear to me that the proposer of this project really knows what he wants to do.

I do not have an appreciation for the need of this project.

A critical issue in electronics manufacturing. Affects manufacturing floor space, cycle time, cost, performance in field. Resources do not match need. Have direct experience and am confident of estimate.

The approach is just a statement of good intentions.

This is design and not manufacturing and I really don't understand the significance of it!

Again, far reaching implications. Product test performance is used as a basis for existing product design as well as new systems costing/bidding. Many systems are "over-tested" simply because there is no knowledge-base for doing otherwise!

Mediocre project compared to others. Probably fits into unit processes area.

Vital to electronics assembly and test based in personal experience in a number of companies and situations.

Good project.

A source of information on this would be Prof. Douglas Marriott, U. of Illinois.

Still don't agree it is applicable to structural parts.

It's not stated, but a major payoff would be in the area of marketing research. Product life cycle planning could be more easily done, with the larger result of making more clear necessary company strategic issues and decisions. I think this proposal needs more work but there are some really good potential benefits of applying AI here.

This project is rated highly because of its contemporary interest, visibility, and clear importance.

Not a manufacturing problem - engineering and design.

Project 15

I don't believe that good planning software is available, as stated. I believe graphic feedback and simulation, with statistics about uncertainties, will be critical for complicated tasks.

Integration of ES with stat packages for intelligent use of statistics is a very worthwhile activity that could be done in a short amount of time. In general, aids for using tools in a more intelligent fashion is a highly desirable goal.

We are working on a similar project in my company. My projected estimate is lower than the ones stated on this statement.

Analysis of manufacturing will become a major consumer of resources.

I do not see anything really being proposed in this project other than what is done separately by the packages now.

I believe it's quite feasible.

Project is too vague. Why do we really need this work?

6 man years is too much for the benefit.

Integrate with Projects 7 and 9 to form decision support package for simulation.

Projects 6, 9, and 15 should all be combined.

I like the idea of using AI tools to front-end OR packages.

Needs more delineation.

Very important to provide feedback under conditions with corsiderable variation (uncertainty) - simulation and statistical information provide invaluable insight. I still disagree that most of the "plarning" software exists, as assumed, and that dramatically affects required resources. Further, how do you "use intelligence" to "modify" a plan or schedule based on statistical information. I have spent 4 years working or determining how uncertainty in spatial relationships is compounded in order to address the correct development of plans that can succeed given accuracy constraints on some relationships.

Project 16

Response does not address this issue.

Rule based systems are too shallow to produce these explanations effectively. Some sort of causal model or qualitative physics approach would be better. The program should "understand" the origin of the defects rather than just identify them by rules.

I think 8.5 my is too much effort.

C1: Perhaps feasible in electronics manufacturing or for a ridgedly structured cell environment, but determining the cause of defects produced in a shop with manually controlled machines by looking only at the end result is ridiculous.

C4: There are a number of inductive techniques coming on the open market (i.e., EXPERT-EASE) which directly address this problem. Therefore, I don't see this pushing SOA.
C6: Seems well-estimated to me.

Note: The "Achilles Heel" of this project is that it assumes the existence of a large amount of data! Basically, you must instrument every process parameter capable of being a casual factor of a given condition. Data of this scope/quality doesn't ordinarily exist in a manufacturing enterprise (at least not now)...big practical problem!

Different approach, use causal model. This would be an advance in the state-of-the-art if done using some sort of causal reasoning.

This had the highest importance rating. In a meeting with GM, Ford, and Chrysler engineers about 18 months ago, a very similar topic was emphasized as important.

Very important, fundamental project but appears to fit under unit processes.

I still think that with sufficient inspection data this work can be accomplished in less than 8.5 MY.

Great idea, but I think some application in industry is possible in addition to basic research.

Project 17

Payoff and contribution are factored by the selection of die casting and injection molding processes. More technology change and foreign competition prove areas would improve.

Watch out! We're talking about eliminating Industrial Engineers!

A source of information on this would be Prof. K. K. Wang, Mechanical Engineering Department, Cornell University.

More dynamic area would have higher payoff. MANTECH emphasis not new knowledge of the science.

Project 18

C4: MCDG isn't AI based but it has addressed may of these issues.

People have been trying to do this for years. I don't believe the estimated resources are even close.

This project has very little relevance to the CAD and development of a single data base relevant in the design in complex aerospace manufacturing systems.

The project is too all-encompassing to be feasible.

AI techniques for design will advance the SOA.

Great idea, but I really do feel the time estimate is low.

Often overlooked is the support E.S. can provide in conceptual and preliminary design. A legitimate thrust is the area of AI for design of which this is a subset.

Project 19

Yield to others who know more about this area.

A design improvement which will impact manufacturing only to the degree manufacturablitt is or is not considered. The proposed contribution does not appear to be a primary objective - mainly application of existing knowledge.

Projects of this type is sorely needed, none exist today.

Milestones indicate an emphasis on graphics which is not the issue. Issue is representation of information.

Fantasmagorical! While some IE's might object to it, this project really hits on one of the biggest (if not the biggest) problems still faced by industry today. The problem has been around since the Industrial Revolution, but it has never been solved. This idea really could be the solution to it. Of all the ideas submitted, this one should receive the highest priority for future work.

Had 5th place when ranked by importance. The high ratings for design-related projects reflect the need for improvements in the design process.

Graphics focus misses the real issues. Proposer needs to clearly understand relationship between form and content of computer languages and systems.

Limited to mechanical design and would have to be constrained to certain objects or classes. The science base exists; they would apply it and develop new tools rather than technology.

Probably qualifies as exploratory development. Lots to do before we can evaluate how to approach the issue.

Still seems to short-change the complexity of 3D geometrical reasoning. "Feature" has wide connotations. Does the system "provide feature detection" because the feature information is called out "a priori" in model definition?

Project 20

For the reasons I gave for Project 5, I feel a process planning system that relies heavily on engineering input and an expert system can be developed that has significant importance to manufacturing, particularly to the aerospace industry.

C1: The approach "...just build an expert system to do..." is to simplistic and indicates low experience.

Think project topic is important. Do not believe approach will allow project to be completed in anywhere near the 3 calendar years. Not enough homogenity in this area to allow this degree of generalization to occur.

I think this is an extremely difficult problem. A system that can do CC from the feature data automatically will be making a big contribution to manufacturing technology.

If you were to use AI, you don't need CC. The entire process is automated, and CC is only for assisting the planner.

C5: We are deeply involved in this activity and have already attempted some of the approaches suggested by this project. The project is doable but not in this manner.

Too long - the capability now exists. Should be a 10 MY effort for near-term implementation as manufacturing technology.

This is similar to other proposals, but it has as much merit as them anyhow. The areas of Group Technology Classification Coding and Generative Process Planning all need - and deserve - AI support.

Experience in building this type of system has taught us that the there is much more effort required for this than the author seem to realize.

Here is area where there are real experts - ideal for application of expert systems.

Probably qualifies as exploratory development. Lots to do before we can evaluate how to approach the issue.

APPENDIX C

INTELLIGENT INFORMATION HANDLING

This appendix reflects the results from the deliberations of the Intelligent Information Handling Panel. It is organized as follows:

DESCRIPTION	PAGE
Sub-Panel White Paper	C-3
Panel Specific Criteria	C-7
Candidate Projects	C-9
Round 3 Assessment Statistics	C-47
Reconciliation Comments	C-51

It should be noted that the I^2H Panel undertook a rewrite of selected projects. These have been numbered with an R and are behind the project that served as their genesis (i.e., 2R, 8R, etc.).

WHITE PAPER

FOR

INTELLIGENT INFORMATION HANDLING

DEFINITION

Intelligent Information Handling (I^2H) for manufacturing comprises a body of evolving procedures and techniques for bringing expert human knowledge to bear on manufacturing problems. The procedures are implemented in software, and exemplify various AI techniques for the analysis, extraction, and representation of expert manufacturing knowledge. I^2H builds upon current manufacturing expertise to establish a powerful new information handling methodology. Its novelty and power are due to the unique knowledge base that is created when human expertise is systematically combined with factual information to drive the manufacturing process. This knowledge base is unique because it:

- operates in a distributed environment.
- integrates information and data from many different sources.
- facilitates the application of problem-solving knowledge to manufacturing.
- derives its knowledge from heterogeneous sources.

The overall emphasis of I^2H is on the automation of manufacturing knowledge and its application throughout the manufacturing cycle.

MOTIVATION FOR RESEARCH

Current deficiencies in distributed manufacturing information systems point out the need to research and develop intelligent information handling systems. Current information systems are characterized by slow response time, out-of-date and sometimes inconsistent data, and incompatible heterogeneous data base systems. Furthermore, the present systems are large and complex, making it difficult to understand and maintain the entire structure and volume of data. It is sometimes difficult to produce suitable reports, given the constraints of the data structure. One major void is the inability to reference geometric data in terms of features. Current systems do not offer user-friendly interfaces. These needs drive the requirement for better information systems, that is intelligent information handling.

CHARACTERISTICS OF AI TO HELP INTELLIGENT INFORMATION HANDLING

The purpose of intelligent information handling is to provide the right information to the decision makers. The request for the desired information is usually articulated imprecisely. Natural language interfaces ease the literacy required for interacting with the system. AI concepts of intentions, themes, scripts, and conceptual dependency are useful in understanding questions which are inexact. Reasoning characteristics of AI systems provide the much needed inferencing capability for deriving information which is not explicitly mapped out in advance. Logic programming contributes unification. Heuristic search techniques facilitate path selection and navigation through the data bases. Knowledge representation techniques can be used to define the user view and the world model. Knowledge representation techniques can also be used to map the world model into the conceptual schema.

Expert systems technology is a relatively mature AI technology which can perform intelligent information handling for the product and process (CAD/CAM) definition phase, the knowledge acquisition and data generation phase, the resource planning and allocation phase, the production phase, the quality assurance phase, the distribution and logistic phase, and finally the administrative and management facets of manufacturing.

A distributed problem solving paradigm is needed for today's heterogeneous and distributed manufacturing environment. AI can coordinate and synchronize the use of autonomous data bases.

FROM DATA BASE TO KNOWLEDGE BASE

- Transition Stages

Information systems transform raw data to information. This is usually accomplished by organizing data items into patterns that correspond to user views or perspectives. Data base management systems take the process one step further by providing answers to queries that can be posed in a variety of different ways. A data base itself can be thought of as a collection of information items of interest to manufacturing. There are lower-level data bases consisting of operational data as well as higher-level data bases that focus on management problems. The typical elements of a data base are factual items, and current data base systems answer queries by retrieving factual data.

By contrast, a knowledge base consists not only of a body of factual data but also a collection of rules (heuristics) for making inferences from the data. This provides a much greater explanatory power than can be achieved with a data base system alone. The rules constitute procedural knowledge, and are usually extracted from some expert source, such as an experienced human. In manufacturing, the base would contain expert knowledge about manufacturing processes as well as factual knowledge about the product being manufactured.

- Content and Processing of Knowledge Base

An intelligent information handling system will include a set of data bases that are likely to be both distributed and heterogeneous. The usual data base problems of updating, deleting old records, inserting new items, and concurrency control will arise in such an environment. In addition, there will be problems of processing the body of procedural knowledge. These problems concern the rules that are to be invoked under specified circumstances, the choice of one course of action over another, the justification for such a choice, the consequences of a given decision if it were taken, the impact of the decision on the manufacturing process, and so on.

The knowledge base will be managed by another body of inferential techniques (inference engines) designed to handle this kind of higher-level processing. The content of the knowledge base will be expert manufacturing knowledge, and the inferential rules will judge how and when the knowledge is to be invoked. Design knowledge and product history must also be incorporated in the system. Relevant knowledge must be extracted and represented to facilitate efficient processing to support the needs of different users.

- Variety of Users

The man-machine interfaces, enhanced by AI, can be improved to support the needs of a wide variety of users. The users of the system will include for example, managers, operators, and designers. Managers require global views of plant operation and status, while the operators will need detailed knowledge of particular processes. Designers will need knowledge concerning manufacturability, maintainability, testability, marketability, costs, and design data. Any product being manufactured can be represented in many different ways, and the role of the knowledge-based system will be to support these different representations.

GOALS

The goals of the research of AI applied to intelligent information handling are to provide solutions and foundations for solutions for advanced manufacturing needs. These include short-range goals that apply AI solutions to existing manufacturing data problems and extend to long-range goals for AI solutions that require new views of manufacturing. One underlying concept in these goals is knowledge, its capture, utilization, and manipulation. This research has at its core the intelligent handling of manufacturing data. Broader goals include: strengthening national competitiveness by improving quality, productivity, reaction time, and cost effectiveness of batch manufacturing; contributing to the science and technology base supporting this area; and providing educational opportunities that increase the number of people skilled in this area.

OBJECTIVES

The following research objectives address the preceding goals:

- Establish a methodology for utilizing existing manufacturing data bases from a knowledge perspective. Such a perspective would allow reasoning about the data in the data base.

- Extend traditional relational data base constructs so that the data base has knowledge built-in. This new type of knowledge based information system would have features of relational data bases and of knowledge systems.

- Create a model which facilitates the integration or combination of existing data bases. Included would be a tool to facilitate mapping between data storage methods, a procedure to translate (map) between the data storage methods, and a procedure for translating requests formulated in one query language to corresponding requests of another query language.

- Provide a mechanism to perform automatic geometric data interpretation.

- Define a mechanism for distributed intelligence in the manufacturing domain that insures security, establishes a global data base, and provides for synchronization and concurrency of data.

- Provide hardware designs to support the increased performance requirements of AI architectures.

- Develop knowledge acquisition and representation techniques for manufacturing.

- Develop an AI tool for the development of intelligent information handling systems.

INTELLIGENT INFORMATION HANDLING PROJECT ASSESSMENT CRITERIA

USE THE FOLLOWING SCALE FOR CRITERIA 1 THROUGH 4

1	2	3	4	5	6	7	8	9
Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree

C1. FEASIBILITY. The project is feasible in terms of:

- Technical Feasibility - Are there known constraints that make the selected problem impossible or too difficult to solve given the proposed approach? Is there adequate knowledge of related work in this area? Have similar attempts failed? If so, what guarantee or likelihood is there that this project will succeed?

- Availability of Expertise - Is there adequate access to a source of expertise, human, or otherwise? Is there a suitable plan for extracting the knowledge from the expert source?

- Soundness of Technical Approach - Is the research plan clearly set forth and justified? Is the methodology properly explained? Is the plan coherent? Is it logically arranged? Are there adequate check points to measure progress? Does the plan show a good understanding of the problem?

C2. IMPORTANCE. The project is important when assessed in terms of the categories listed below:

- utility across the manufacturing industry,
- enhancement to product quality,
- reduction in cycle time,
- extension of capability,
- productivity improvement,
- broad applicability.

C3. CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE. This project contributes to the manufacturing science base and AI. This contribution may be at any point in the spectrum of pure research to applied technology. The project demonstrates originality in its application of existing techniques or creation of new ones.

C4. PAYOFF. The project contributes to cost reduction, product quality, process responsiveness, and reduction of support services. Support service cost drivers include software engineering and data management.

USE THE FOLLOWING SCALE FOR CRITERIA 5 AND 6

1	2	3	4	5	6	7	8	9
Very Low		Low		Agree		High		Very High

C5. TIME ESTIMATE. The time estimate (in calendar years) is reasonable in light of the project's objective and approach.

C6. RESOURCE ESTIMATE. The resource estimate is reasonable in light of the project's objectives and approach.

FOR WORKSHOP USE
CODE # 1

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES   ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: 2nd Generation Data Base Machine

PROBLEM DEFINITION/PROJECT OBJECTIVE: Create a data base machine to service tomorrow's distributed intelligent environment. Intelligent decision making mechanisms need high speed devices to perform inferential based retirval of data and knowledge. In a highly distributed environment, there is a need for a common repository which manages shared data and knowledge. Inferential capability needs to be added to today's 1st generation data base machine. Derivation-based retrieval allows for inexact mapping of information and implicit declaration of relationships.

PROJECT DESCRIPTION/APPROACH: Design a prolog-like environment in hardware. Unification and defer binding is used on both the data, conceptual schema and meta-conceptual schema to facilitate derivation of information. One approach is to extend existing relational data base and accompanying query language with features such as recursion and data structure. This approach takes maximum advantage of today's technology and paves the way for a smooth transition. An alternative approach is to design a completely new machine with logic programming as its foundation. The bridge to today's data base structure will be an add-on item for the 2nd approach.

IMPORTANCE TO MANUFACTURING: One of the most critical and knowledge intensive task in manufacturing is in the interpretation of the engineering drawing. Most of the producibility, planning, control, and logistic decisions are made based on how the engineering drawing was interpreted. Interpretation is based mostly on implicit or derived information. A high speed device which performs derivation-based retrival is a springboard to automatic understanding of engineering drawing. Another important aspect is that this 2nd generation data base machine will ease the configuration management of manufacturing knowledge in a distributed environment. Controlling a common repository is simpler than controlling disbursed knowledge based.

FOR WORKSHOP USE
CODE # 1

CONTINUATION OF (project title) 2nd Generation Data Base Machine

POTENTIAL PAYOFF (quantitative, if possible): A device which can service multiple intelligence decision makers reduces the storage and computational requirement of each. It also reduces the manpower requirements for configuration management and maintenance of shareable knowledge. It would also relax the need for special purpose machines for the decision makers. It will also facilitate and minimize the manufacturing applications which are derivation-based.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: It is a major contributor in the development of the intelligence system. It is a much needed general purpose tool which is missing today.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

Model Construction	0-16 mo.
Software Development	12-24 mo.
Hardware Design	12-24 mo.
Integration	24-30 mo.
Demonstration	30 mo.
Refinement	36 mo.

RESOURCE REQUIREMENTS:

1 - System Engineer for 3 MY

2 - Software Engineers for 6 MY

2 - Computer Engineer for 6 MY

1 - Communicative for 3 MY

2 - Data Base for 6 MY

Hardware - 4 Engineers - Work Station or Periferals

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 2

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Manufacturing Scheduling and Resource Management Using Intelligent Information Handling

PROBLEM DEFINITION/PROJECT OBJECTIVE: The scheduling and resource management of global facilities and multiple manufacturing resources (internal and external) can be addressed using intelligent information handling (I^2H) and artificial intelligence to model an entire manufacturing capability. That is a communication data base with linkages to product/process definition, manufacturing plans, production, quality, distribution, and management.

PROJECT DESCRIPTION/APPROACH: Create a knowledge base of global resources (plants, machines, people) and a model of the generic manufacturing process. Using artificial intelligence techniques, model an expert system, to expedite information and product flow through the sequential manufacturing model for each product (product class) fabricating a real time production and resource schedule. Related work includes programs in LISP (FAITH, DEVISOR & CONNIVER) at JPL to schedule and manage deep space probe including "processes" like "fly by", camera management, antennae management, health and status, etc.

IMPORTANCE TO MANUFACTURING: Manufacturing systems (people, facilities & data bases) could learn and improve a manufacturing process through maintenance of a single global model and the model would reflect schedule and resource utilization in real-time. Intelligent information handling would facilitate scheduling and resource management of a global manufacturing environment, emperically collecting real-time performance statistics to feedback to the model.

FOR WORKSHOP USE
CODE # Z

CONTINUATION OF (project title) Manufacturing Scheduling and Resource Management Using Intelligent Information Handling

POTENTIAL PAYOFF (quantitative, if possible): Optimum schedule and resource utilization for a global manufacturing capability that could handle multiple plants (subcontractors) expediting all products from a globally optimum view. Goal would be to improve productivity by, at minimum, 25%.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: (1) Proof that multiple cooperative expert systems can use a global intelligent information system in a coordinated manner. (2) Formalization of manufacturing models for specific products and technologies.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (1) Global resource set partitioned (2) Personnel and skills inventory, complete. (3) Rough model established with functional partition (4) Product knowledge representation and knowledge acquisitions complete (5) Model operational (6) Process (multiple) monitor sched. & res. mgr (7) Exped. oper (8) Proj. comp.

	Year 1	Year 2	Year 3
Milestones	(1) (2) (3)	(PDR) (4) (CDR)(5)	(6) (7) (8)
Time	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12

RESOURCE REQUIREMENTS: 24 MY + $330,000 computing hardware

3 Knowledge Engineers - 3 yrs = 9 MYRS

4 Programmers (AI) - 3 yrs. = 12 MYS

3 Symbolics 3640 computers @ $60K = $180 K

1 Symbolics 3670 computer @ $150 K = $150 K

1 Mgr. - Project Engineer - 3 yrs = 3 MYS Estimated @ $2,500,000.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 2R

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

___ UNIT PROCESSES ___ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Manufacturing Scheduling and Resource Management Using Artificial Intelligence

PROBLEM DEFINITION/PROJECT OBJECTIVE: The scheduling and resource management of facilities and multiple manufacturing resources (internal and external) can be addressed using artificial intelligence to represent an entire manufacturing capability. The representation would draw from a data base integrating/process definition, manufacturing plans, actual production, and quality control.

PROJECT DESCRIPTION/APPROACH: Create a knowledge base of available resources (plants, raw materials, machines, people, etc.) and constraints and a model of the generic manufacturing process. Using artificial intelligence techniques, develop an expert system to expedite information and product flow through the sequential manufacturing process for each product (product class), generating or revising (using feedback) a real-time production and resource schedule. Related work may include programs in LISP (FAITH, DEVISOR & CONNIVER) at JPL to schedule and manage deep space probe including "processes" like "fly by", camera management, antennae management, health and status, etc.

IMPORTANCE TO MANUFACTURING: Manufacturing processes could be improved by use of an integrated model reflecting schedule and resource utilization in real-time.

FOR WORKSHOP USE
CODE # 2R

CONTINUATION OF (project title) Manufacturing Scheduling and Resource Management Using Artificial Intelligence

POTENTIAL PAYOFF (quantitative, if possible): Optimum schedule and resource utilization for a total manufacturing environment would result in more efficient production.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Formalization of a generic manufacturing model. Demonstration that models of the product life cycle (product/process definition, planning, production, and quality control) can be integrated in an expert system that uses feedback for optimum control.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (1) Resource set partitioned (6 mo). (2) Preliminary model established with functional particion (15 mo). (3) Product knowledge representation and expert knowledge acquisitions complete (24 mo). (4) Prototype operational (36 mo).

Year 1	Year 2	Year 3
1 2 3 4 5 (1) 6 7 8 9 10 11 12	1 2 (2) 3 4 5 6 7 8 9 10 11 12 (3)	1 2 3 4 5 6 7 8 9 10 11 12 (4)

RESOURCE REQUIREMENTS:

21 MY + computing hardware + subject matter experts

3 Knowledge Engineers - 3 yrs. = 9 MYRS	Subject Matter Experts
3 Programmers (AI) - 3 yrs. + 9 MYRS	1 yr. each total
3 Symbolics 3640 computers @ $60 K = $180 K	(throughout project)
1 Manager - Project Engineer - 3 yrs = 3 MYRS	

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 3

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: An AI Tool to Assist the Development of CIM Information Systems

PROBLEM DEFINITION/PROJECT OBJECTIVE: This tool will have an intelligent and graphical interface between the CIM system designers and a computer representation of the CIM system (embodied largely in a global data dictionary). The tool will structure the design activity to insure a hierarchical description of the CIM information system, allowing decomposition and editing and viewing in a level by level and level to level mode.

PROJECT DESCRIPTION/APPROACH: 1) Study literature,especially data base design/ modeling, expert systems/advice givers, intelligent editors. 2) Extract important ideas from IDEF(0), IDEF(1), Entity-Relationship model, and expert systems. 3) Design an appropriate data dictionary structure with hooks in it for knowledge and inferencing. 4) Design a mechanism for construction of the data dictionary via the intelligent interface.

IMPORTANCE TO MANUFACTURING: The design of an Information System for Computer Integrated Manufacturing (CIM) is a difficult task. The designers are confronted with a large number (thousands) of entities, relations, and functions that relate in a complex way. Furthermore, the system will be implemented in a distributed computer environment with varying response time requirements. Current tools like IDEF(0), IDEF(1), and S/R modeling are not enough.

Since all CIM systems will have an Information System, the importance of this project is great.

FOR WORKSHOP USE
CODE # 3

CONTINUATION OF (projecttitle) AN AI Tool to Assist the Development of CIM Information Systems.

POTENTIAL PAYOFF (quantitative, if possible): This tool will substantially reduce the manhours needed to produce the CIM Information System design and implementation. It will allow a CIM facility to be constructed in a shorter time frame. It will also improve the quality of the design.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Contributions include a data dictionary, designed with knowledge, as well as a development tool. Some insights and contributions could be made to expert systems, especially with respect to graphical interfaces.

PROJECT DURATION: 2-2½ CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (Times from start date given)

Literature Study (annotated)	4-6 months
Data Dictionary	1-1½ years
System Designed	1½-2 years
System Implemented	2-2½ years

RESOURCE REQUIREMENTS: Powerful LISP/graphical development system required, preferable on a LISP machine or AI workstation.

1 faculty 20% Acad Year, 50% summers for 2-2½ years.

1-2 PhD level students in manufacturing and/or computer science (knowledge engineer)

1-2 Masters level students in manufacturing and/or computer science (knowledge engineer)

Cost - $500,000

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 4

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: An Expert System to Facilitate Design for Manufacturability

PROBLEM DEFINITION/PROJECT OBJECTIVE: Present manufacturing information and CAD/CAM systems are incapable of retrieving geometric designs by features or other attributes, and are unable to relate geometric data to relevant manufacturability data. The objective of the project is to develop a smart system using I^2H that will provide manufacturability advice to the designer.

PROJECT DESCRIPTION/APPROACH: The approach is as follows: (1) extract expert knowledge from human in the areas of design, manufacturing, new product history, (2) represent the different types of knowledge in an expert system. (3) using group technology as a basis, develop procedures for defining similarities between parts dynamically to assist in revrieval. (4) develop intelligent interface between the bodies of knowledge so as to provide expert advice on manufacturability.

IMPORTANCE TO MANUFACTURING: At present, designers work at a disadvantage by meer lack of real knowledge concerning a product's manufacturability, maintainability, testability, marketability, and cost. In addition, relevant design data are difficult to retrieve in a straight-forward fashion. If successful, the project would point the way toward a truly integrated design and manufacturing environment.

FOR WORKSHOP USE
CODE # 4

CONTINUATION OF (project title) An Expert System to Facilitate Design for Manufacturability

POTENTIAL PAYOFF (quantitative, if possible): The payoff is to be measured in terms of shortened time to develop and manufacture a product, cost savings in bringing it to market, greater productivity, fewer product failures, and better quality assurance.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The major contribution would be to our understanding of the dynamic interactions between radically different bodies of data, and to the development of a body of problem-solving knowledge incorporated in an intelligent system supporting the entire manufacturing cycle.

PROJECT DURATION: 4 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (1) extraction and representation of manufacturing and design knowledge (1.5 yrs.) (2) incorporation of knowledge in a prototype expert system. (2 yrs.) (3) development of procedures to define similarities dynamically (3 yrs.) (4) testing of prototype (4 yrs.)

RESOURCE REQUIREMENTS: Access to sources of expert knowledge (human and textual); use of computer facilities (e.g. VAX 11/780, Symbolics 3600); expert system software; 12 man years of senior personnel; 20 man years of junior personnel; $2 million for total effort.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 4R

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: A Designer's Assistant to Facilitate Mechanical Design

PROBLEM DEFINITION/PROJECT OBJECTIVE: Engineering design has a major impact on product life-cycle cost (LCC), quality, product cycle time, etc. Designers have limited access to certain classes of data from downstream functions that impact these product factors. The objective of this project is to develop a system, using appropriate I^2H and computing technologies, that will provide advice to the designer on manufacturability, inspectability, LCC factors, and other important product factors.

PROJECT DESCRIPTION/APPROACH: (1) Select a family of parts for the project. (2) Extract expert knowledge in the areas of interfacing design and manufacturing, product history, LCC factors, and quality and reliability. (3) Where possible, mechanize the knowledge in expert systems and other computer technologies (4) Use techniques such as group technology to assist in data retrieval from a product data base. (5) Develop a user interface to provide expert advice to designer (6) Demonstrate concepts with a prototype demonstration for the selected family of parts.

IMPORTANCE TO MANUFACTURING: At present, designers work at a disadvantage by having limited knowledge concerning a product's manufacturability, maintainability, testability, and LCC. By providing designers better access to appropriate knowledge, the project will aid in product LCC reduction, product cycle-time reduction, and better quality and reliability.

FOR WORKSHOP USE
CODE # 4R

CONTINUATION OF (project title) A Designer's Assist to Facilitate Mechanical Design

POTENTIAL PAYOFF (quantitative, if possible): Shortened time to develop and manufacture a product, savings in LCC, greater productivity, fewer product failures, and better quality assurance.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: The major contribution will be an understanding of the interactions between different bodies of knowledge and practice associated with different functions within the total product life cycle. A better understanding of the opportunities and limitations of current techniques for intelligent design assists will be developed.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

(1) Extraction and representation of appropriate knowledge (1.5 yrs)
(2) Where possible, mechanization of the knowledge using appropriate computing technology (2 yrs)
(3) Development of prototype ($2\frac{1}{2}$ yrs)
(4) Testing of prototype (3 yrs)

RESOURCE REQUIREMENTS: Access to selected manufacturing process and product data. Access to sources of expert knowledge (human and textual). Use of computer facilities; expert system software.

6 manyears of senior personnel; 9 manyears of junior personnel

$2 million for total effort

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 5

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES ___ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: ICONS for Manufacturing Including Chernoff Variations

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of this project is to develop standard symbolic representation(s) of manufacturing elements and by variation, depict the state of the manufacturing system.

PROJECT DESCRIPTION/APPROACH: Artificial intelligence techniques, tools, and methodologies will be used to determine which data best represent manufacturing elements, how states are defined and differentiated and what symbology best communicates these elements and their state. This symbology will be linked to the Intelligent Information Handling System for generation. The symbology will be tested for acceptability by management and staff. Accepted symbology will be produced as a national standard.

IMPORTANCE TO MANUFACTURING: Manufacturing has many diverse elements (inventory, costs, quality, schedule) at many levels of indenture (raw material, components, modules, sub-assemblies, assemblies, completed procedures, and delivered product) for each phase of a product life cycle (concept, design, development, production, use, modification) in each phase of a factory life cycle (start-up, transient, steady state, correction). Standard symbology is needed to depict these elements and their state in order to permit rapid and accurate communication for management decision to adjust processes or continue as is.

FOR WORKSHOP USE
CODE # 5

CONTINUATION OF (project title) ICONS for Manufacturing Including Chernoff Variations

POTENTIAL PAYOFF (quantitative, if possible): Many resources are required to assemble and array many data in a variety of formats to communicate the state of manufacturing to management. Management requires much time to assimilate and integrate these data. The payoff will be reduction in time to assemble, array, and assimilate these data. Potential payoff is 85% reduction in assimilation time.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

(1) Manufacturing symbology standards
(2) Graphic symbolic processing
(3) Universal knowledge transfer

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (1) Study complete (2) Draft symbology (3) Symbology variations complete (4) ICON man-machine interface complete (5) I^2H interfaces defined (6) Prototype, operational (7) Operational parametric simulation and demonstration (8) Demonstration complete (9) Standards published (10) Standards accepted (11) Project complete

RESOURCE REQUIREMENTS:

(1) Knowledge Eng X 1 X 3 yrs = 3myrs
(2) Programmers (AI) X 2 X 3 yrs = 6 myrs
(3) Mfg. Expert X 1 X 5 yrs = 5 myrs
(4) Computer System (AI) @ $90,000 = $90,000
(5) PE X 1 X 5 yrs = 5 myrs

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near term)

FOR WORKSHOP USE
CODE # 6

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

XX INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Group Technology Learning Mechanisms for Assembly

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of the project is to build a group technology (GT) coding and classification system that will support assembly process planning. The system will: (1) classify individual assembly steps for process selection; and (2) implement a learning mechanism so the coding rules and classification rules evolve over time based on actual assembly plans generated by the assembly planning system.

PROJECT DESCRIPTION/APPROACH: The GT system will support an existing assembly planning system. The GT system will implement the traditional functions of attribute coding and problem classification. These functions will be driven by a data base of rules for the classification scheme and the definitions of the attributes. Behind this rule base will be an experience data base of past assemblies and associated plans. As the experience feature design processes, which will modify the rule base controlling the coding and classification. Over time, the GT system will converge to providing optimal classifications for assembly planning.

IMPORTANCE TO MANUFACTURING: The basis of GT problem solving is that similar problems have similar solutions. The purpose of coding and classification are to define similarity classes among problems. The benefits of GT-based problem solving are: stability of the planning process; use of past experience to improve efficiency and accuracy; and the ability to use analysis of past decisions in future planning. The major problems in applying GT to assembly are in defining what it means for two problems to be similar. This system will demonstrate how past experience can be codified, analyzed, and used to modify the definition of similarity used by the GT system.

FOR WORKSHOP USE
CODE # 6

CONTINUATION OF (project title) Group Technology Learning Mechanisms for Assembly

POTENTIAL PAYOFF (quantitative, if possible): An assembly plan is valuable in two ways: it describes how the assembly is to be created, and it is a record of the fact that that plan creates that assembly. The latter benefit, however, is rarely realized. Ironically, in an automated environment, where the information is more readily available, there is less chance that it will be used than in a manual shop, where the planner learns from experience. This can be integrated over time to provide drastic improvements in efficiency and stability of the planning process. It is estimated that throughput can be increased by up to 70% through the use of GT-based planning with a good classification scheme.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Learning mechanisms in rule-based systems are still a research topic. The learning mechanism to be used involves using the explanatory capabilities of rule-based planning systems to capture knowledge about what part attributes were important in the decisions made. This is a novel use of expert systems for learning, and will provide insight into the use of explanation as a learning mechanism.

PROJECT DURATION: 2 CALENDAR YEARS

MAJOR MILESTONES (include timeframe): (times given are from start of project)

1) Implement Attribute Coding System: 4 months; 0.5 SY
2) Create Initial Attribute Definition Rules: 6 months; 0.5 SY
3) Implement Classification System: 9 months; 1 SY
4) Define Experience Data Base Structure: 12 months; 1 SY
5) Generate Test Data: 12 months; 0.5 SY 6) Implement Attribute Inference System: 16 months; 1 SY 7) Implement Classification Inference System: 20 months; 1 SY 8) System Demonstration: 24 months; 0.5 SY

RESOURCE REQUIREMENTS: 6 staff-years: $550K; AI computer system: $30K

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) XX Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 7

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Software Development Assistant

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective is to provide software developers with a tool to assist them when performing software design and development, possibly including editing tools, debuggers, testing aids, maintenance assistance, etc.

PROJECT DESCRIPTION/APPROACH: 1) Identify what steps in software development can best utilize intelligent assistance. 2) Gain expertise of software developers and develop the intelligent assistant. 3) Develop a natural language interface for the system. 4) Refine the system. (It may be best to integrate 2 and 3 above)

IMPORTANCE TO MANUFACTURING: The purpose of manufacturing is to produce a product. If a great deal of time and money is spent on software development, it holds up production. We want to speed this process.

FOR WORKSHOP USE
CODE # 7

CONTINUATION OF (project title) Intelligent Software Development Assistant

POTENTIAL PAYOFF (quantitative, if possible): Software development has become one of the most costly parts of any kind of manufacturing system development. If software development time can be shortened while increasing reliability and completeness of software, great savings will be realized.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Contributes a generic tool to assist manufacturing software developers in shortening development time and insuring completeness of software development. Contributes to expert system/natural language interface interaction research.

PROJECT DURATION: 5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

1)	Identification of software development areas needing intelligent assistance	6 mo.
2)	Knowledge collection/Expert system development	2 yrs.
3)	Natural language interface development	2 yrs.
4)	System refinement	6 mo.

RESOURCE REQUIREMENTS: Knowledge Engineers: 3 Full time, 3 yrs. total (1,2,4 above plus possible interaction in #3). Experts (manufacturing software developers): 4-5 (for concensus) ½-time, 5 years. For #3 above: 2 ½-time faculty (2 yrs.), 3 ½-time PhD students (2yrs.). Hardware/software: preferably a LISP machine with an expert system development tool such as ART by Interface Corp.

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term)   X Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 8

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Design and Implementation of a Data Model for Manufacturing

PROBLEM DEFINITION/PROJECT OBJECTIVE: A data base which can support expert systems used for generating manufacturing instructions must support versioned data and data types appropriate to manufacturing. The objective of this project is to develop data types which accurately reflect the world of manufacturing, and to implement this model using a relational data base.

PROJECT DESCRIPTION/APPROACH: First develop the specification for abstract data types corresponding to devices (robots, machine tools, fixtures, etc.), parts, sensors, and so forth. This work will be guided by the ideas of Sowa, Reiter, Brodie, and others on applying concepts from mathematical logic and logic programming to data base design. Since currently available relations DBMS's do not recognize these semanitically complex entities it will be necessary to build a data base interface which manipulates these data types while maintaining their semantic integrity.

IMPORTANCE TO MANUFACTURING: As expert systems are incorporated into the manufacturing process the interface of the expert system to the corporate data base will become essential. Since many such systems are "object oriented", the data base will have to deal in some way with this object orientation. Otherwise the interface between the expert system and the data base becomes excessively complicated. This project will result in a flexible and maintainable interface between expert systems and relational data bases.

FOR WORKSHOP USE
CODE # 8

CONTINUATION OF (project title)

POTENTIAL PAYOFF (quantitative, if possible): This is a necessary step in applying knowledge-based systems technology on the large scale needed to support many manufacturing operations.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Contributions include the development of data types, and operations on those data types, which are appropriate for representing the manufacturing environment. This is needed not only for data base design but also for construction of languages and user interfaces to support off-line programming of robots, machine tools, coordinate measuring machines, and so forth.

PROJECT DURATION: 2 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

Literature study	4 - 8 months
Development of data types	8 - 12 months
Design of data base interface	8 - 12 months
implementation of data types in a relational DBMS (conceptual schema to support manufacturing)	12- 18 months
construction of interface	12- 18 months
~~test interface with expert system~~	~~18- 24 months~~

RESOURCE REQUIREMENTS:

Relational data base manager

List environment (workstations)

2 people full time the first year

4 people full time the second year

cost: $700,000

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term) x Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 8R

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

____ UNIT PROCESSES

____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Integration of Knowledge Based Systems in Manufacturing

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of this project is to develop a capability to support the access and update of current manufacturing data base systems from knowledge based applications and vice versa.

PROJECT DESCRIPTION/APPROACH: First, perform an analysis of manufacturing knowledge representation and organization requirements for manufacturing ES applications. Secondly, design abstract data types to support the mapping from these knowledge organizations to current manufacturing data base structures. This work would build on the ideas of Sowa Reiter, Brodie, and others on applying concepts from mathematical logic and logic programming to data base design. Finally, the project would produce a a set of software utilities to implement these data types in knowledge base systems. Currently, available manufacturing DBMS's do not recognize semantically complex entities. It will be necessary for the developed data base interface to manipulate these data types while maintaining their semantic integrity.

IMPORTANCE TO MANUFACTURING: As expert systems are incorporated into the manufacturing process, the interface of the expert system to the corporate data base will become essential. Since many such systems are "object oriented", the data base will have to deal in some way with this object orientation. Otherwise the interface between the expert system and data base becomes obscure. This project will result in a flexible and maintainable interface between expert systems and relational data bases.

FOR WORKSHOP USE
CODE # 8R

CONTINUATION OF (project title) Intelligent Integration of Knowledge Based Systems in Manufacturing

POTENTIAL PAYOFF (quantitative, if possible): This is a necessary step in applying knowledge-based systems technology on the large scale needed to support many manufacturing operations. It enhances basic functionality with the state-of-the-art AI and computer technology in manufacturing.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

Contributions include:

- Identification of common manufacturing knowledge representation and organization requirements.
- Development of data types appropriate for mapping these representations to manufacturing data base structures.
- Provision of a set of utilities for effecting KBS to DBMS interfaces.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

- Requirements Analysis
- Development of data types
- Construction of interfaces
- Integration of utilities
- Test interface with expert

RESOURCE REQUIREMENTS: Access to Relational, Network, hierarchical DBMS's
LISP environments
2 FTE Senior & 4 Junior FTES
Cost $900,000

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

CODE # 9

PROJECT DESCRIPTION FORM

APPLICATION AREA: (please check one)

_____ UNIT PROCESSES _____ MANUFACTURING SYSTEMS
__X__ INTELLIGENT INFOMRATION HANDLING

PROJECT TITLE: Standardized Knowledge Representation Scheme for Product/Component Functions

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of this project is to develop a standardized way of representing that knowledge pertaining to the function of a product, or product component, in a larger system.

PROJECT DESCRIPTION/APPROACH: AI knowledge representation techniques (such as conceptual dependency, state analysis) will be examined to evaluate their applicability to the problem of representing the function of a component in a system (i.e., why is it there, how does it contribute to the entire system, what are the critical factors in the performance envelope?). The resulting symbology will be applied to a number of test cases to insure the general applicability of the technique. The accepted KR scheme will become a national standard.

IMPORTANCE TO MANUFACTURING: Many relationships in the manufacturing enterprise depend upon the functional dependence of the different components of a system, not just the geometric dependence (size, shape, etc.) or logistics (procurement) considerations. True optimization of a manufacturing system (design-to-cost, producibility engineering) will only occur when such knowledge is considered in the analysis, so that the relationships may be adjusted accordingly. It follows that a way of representing such knowledge is needed, and that a standardized method for this is highly desirable in order to achieve rapid and accurate communication among all manufacturing areas (or even vendors).

POTENTIAL PAYOFF: Skilled resources with high domain-knowledge levels are currently needed to perform the analyses that use this information. There is currently no standard vehicle for an enterprise to manage this information (other than managing the people containing it). The proposed scheme would function as a personnel-independent knowledge base, enable rapid knowledge retrieval for use in future designs, aid the training process for new personnel involved in the design process, aid the exchange of like data between different manufacturing/ design areas, and facilitate upstream cost/function tradeoff studies.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:
(1) Manufacturing standards

PROJECT DURATION: 3 calendar years

0041r

CODE #9

MAJOR MILESTONES (include timeframe):

(1) Problem definition	1 myr (2 x 6 mo.)
(2) KR scheme analysis complete	.5 myr (1 x 6 mo.)
(3) Draft symbology complete	.25 myr (1 x 3 mo.)
(4) Operational prototype	.25 myr (2 x 6 mo.)
(5) Selected experiments	1 myr (3 x 3 mo.)
(6) Symbology revised	.25 myr (1 x 3 mo.)
(7) Symbology published	.25 myr (1 x 3 mo.)
(8) Symbology accepted	.5 myr (1 x 6 mo.)

Total 4 myr.

RESOURCE REQUIREMENTS:

(1) Knowledge Engineer
(1) Domain expert (generalist)
(3) Domain experts (specific)
(1) AI computer system (VAX-11/780 w/ LISP or equivalent)

PROJECT CLASSIFICATION:
Manufacturing Technology or Advanced Development (near-term)

rOR WORKSHOP USE
CODE # 10

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

x INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Process Prediction Processor

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of this project is to develop a generic Artificial Intelligent (AI) based run time internal operating systems (OS) subsystem which will analyze the Job queques of an OS using AI driven run time diagnostics for the purposes of determining preprocessing and optimizing potentials in direct support of scalor, vector, and parallel processors required to support manufacturing applications.

PROJECT DESCRIPTION/APPROACH: Determine the requirements for an Artificial Intelligents Process Prediction Processor by building models of the various types of processors and analyzing processing conditions. The solution concepts and designs will be based in advance Artificial Intelligence techniques, tools, and methodologies. Implementation and integration will be in a homogenous and heterogenous distributed computer network environment of manufacturing production.

IMPORTANCE TO MANUFACTURING: The CIM application technologies are beginning to find their way into the production arena and as the demand for information increases, newer faster computers with smarter information handling methods will become mandatory. The processing power of the hardware has physical limits. The operating systems that drive the hardware must compensate. The user in the manufacturing environment has instantaneous needs for new data of high quality and accuracy for making decisions. The problem to be solved is the producing of an Artificially Intelligent Engine that will, where possible, predict with a great deal of accuracy potential occurrences of problem conditions in the work place. Predictions with associated data needs to be presented to the manufacturing decision maker prior to the occurrence with sufficient and reaction time.

FOR WORKSHOP USE
CODE # 10

CONTINUATION OF (project title) Process Prediction Processor

POTENTIAL PAYOFF (quantitative, if possible): A set of software programs which can function in multiple operating systems environments reducing inefficiency in program execution time, storage, accessability, schedules, configuration management, and administration will increase internal throughput and the overall production capability of a computing environment. Support requirements of production control and data administration people are reduced. Coexistence of scalor, vector, and parallel processing capabilities will reduce the span time of product flow through the manufacturing entities facilities.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: This AI tool is greatly needed today to reduce the size of technical support staff to the computing production environment and to increase throughput of computer production. Few tools are available today in this area of support and those that do exist are not AI oriented. UCC7 is probably the most sophisticated. UCC7 is manually driven and does not perform internal diagnostics or internal optimizations at run time. Run time interactive tools rather than batch tools will provide a quantum leep in manufacturing support.

PROJECT DURATION: 10 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):	4 Yrs.-PHASE I	3YR PHASE2	3YR PHASE3
Model Construction	12 mos.	6 mos.	3 mos.
Requirements Definition	8 mos.	2 mos.	1 mos.
Design	12 mos.	12 mos.	14 mos.
Software Development & Testing	18 mos.	10 mos.	12 mos.
Integration and Testing	12 mos.	6 mos.	8 mos.
Demonstration and Refinement	18 mos.	18 mos.	18 mos.

RESOURCE REQUIREMENTS:

People:		Hardware:	Facilities:
Program mgr. & Tech. Mgr.	Sr. Data Base Adm.	Comm. Netwk.	Computer Rms.
Sr. Oper. Sys. Engineer	Sr. Comm. Engr.	Scalor Comp.	Storage Rms.
2 Sr. Systems Engineers	Sr. Comp. Prod. Cont. Engr.	Vector Comp.	Work Space
6-8 Software Engineers	10-15 Comp. Oper. & Tech. Sup.	Parallel Proc. Comp.	Briefing Space
Sr. Computer Hw. Engineer	2-3 Tech. Writers & Doc'mt Spec.	Peripherals	

PROJECT CLASSIFICATION (please check one):

4Yrs/Phase-1 Basic Research (long-term) 3Yrs/Phase-2 Exploratory Development (mid-term)

3Yrs/Phase-3 Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 11

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES ___ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Design and Implementation of a Decision Support System for Manufacturing Management

PROBLEM DEFINITION/PROJECT OBJECTIVE: There are several different components to managing a manufacturing facility that range from operational questions such as machine scheduling to long-range planning including the design of facilities. The objective is to design and implement a decision support system that integrates analytic tools to do scheduling and planning using expert system technology. A natural language front end, graphics, and forms would be important user interfaces.

PROJECT DESCRIPTION/APPROACH: Study the behavior of human experts in machine scheduling, inventory management, facilities layout, etc., including their use of software packages to carry out specific functions. Develop rules including likelihood factors. Design the data base, forms, graphics, possibly spreadsheets to integrate with expert rules. Implement and test prototype.

IMPORTANCE TO MANUFACTURING: A decision support system that integrates already developed scheduling and planning tools using expert systems should aid significantly in increasing productivity of managers of manufacturing facilities. Advances in M.R.P., scheduling and facilities layout can be integrated with a data base under control of an expert system. The expert system will incorporate knowledge on how these analytic tools should be employed. The manufacturing decision support system should be networked to the corporate information systems.

FOR WORKSHOP USE
CODE # 11

CONTINUATION OF (project title) Design and Implementation of a Decision Support System for Manufacturing Management

POTENTIAL PAYOFF (quantitative, if possible): A decision support system incorporating the many advances in scheduling and planning in an artificial intelligence framework will increase the productivity of manufacturing management.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Applying artificial intelligence techniques to analytic models written in a procedural language should lead to a new understanding of how artificial intelligence and Industrial Engineering concepts can be synergistically combined. Exploration of various reasoning techniques in a manufacturing setting should be significant.

PROJECT DURATION: 2 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

Literature study	4 mos.
Design of data base (specification of fields, tables, etc.)	4 mos.
Development of expert rules for managing and integration of analytic tools	8 mos.
Specification of user interface	8 mos.
Software testing	4 mos.

(some activities will be carried out in parallel)

RESOURCE REQUIREMENTS:

Artificial intelligence environment that integrates data base, spreadsheet, graphics, text processing, natural language processing, procedural programming with expert systems

GURU from Micro Data Base Systems ($30,000)

VAX 11/780 networked with IBM/AT workstations or equivalent

2 senior investigators and 2 graduate students ($200,000)

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term)   x Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 11R

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

___ UNIT PROCESSES ___ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Interface for Manufacturing Management DSS

PROBLEM DEFINITION/PROJECT OBJECTIVE: There are several different components to managing a manufacturing facility that range from operational questions such as machine scheduling to long-range planning including the design of facilities. The objective is to design and implement a decision support system that integrates analytic tools to support expert system technology, scheduling, planning, and decision making. A natural language front end, graphics, and forms would be important user interfaces.

PROJECT DESCRIPTION/APPROACH: Study behavior of human experts in machine scheduling, inventory management, facilities layout, etc., including their use of software packages to carry out specific functions. Based on study results, specify requirements for expert systems in support of decision scenarios. Provide an improved man-machine interface for a manager in his system of support development and test a prototype. The expert system will incorporate knowledge on how these analytic tools should be employed. The manufacturing decision support system should be networked to the corporate information systems.

IMPORTANCE TO MANUFACTURING: A decision support system that integrates already developed scheduling and planning tools, using expert systems should aid significantly in increasing productivity of managers of manufacturing facilities. Advances in MRP, scheduling, and facilities layout can be integrated with a data base under control of an expert system.

FOR WORKSHOP USE
CODE # 11R

CONTINUATION OF (project title) Intelligent Interface for Manufacturing Management DSS

POTENTIAL PAYOFF (quantitative, if possible): A decision support system incorporating the many advances in operations research, within an artificial intelligence framework will increase the use of these OR results by manufacturing management.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Applying artificial intelligence techniques to the development and use of OR models should lead to a new understanding of how artificial intelligence and Industrial Engineering concepts can be synergistically combined. Exploration of various techniques in manufacturing reasoning will significantly improve the general capability of designing information support for manufacturing.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

Requirement Analysis	6 mos.
Design of data base (specification of fields, tables, etc.)	6 mos.
Development of expert rules for managing and integration of analytic tools	12 mos.
Specification of user interface	12 mos.
Software testing	6 mos.

(some activities will be carried out in parallel)

RESOURCE REQUIREMENTS: Artificial intelligence environment that integrates data base, spreadsheet, graphics, text processing, natural language processing, procedural programming with expert systems when someone thinks of old days, old times, old friends.

GURU from MIcro Data Base Systems ($30,000)
VAX 11/780 networked withIBM/AT workstations or equivalent $1,500,000
3 senior investigators and 4 graduate students

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term)   X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

CODE # 12

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Software Tools for System Scheduling

PROBLEM DEFINITION/PROJECT OBJECTIVE: Each manufacturing system has configuration and scheduling problems unique to its environment these can be caused by physical constraints, personnel and equipment availability or supplier reliability. The objective of this project is to develop software tools with the capability of representing a large variety of manufacturing systems and developing an expert configurer and scheduler for each system.

PROJECT DESCRIPTION/APPROACH: Initially one would build a skeletal inference system which would consist of a method of representing the processes in the manufacturing system and some general meta-rules for developing scheduling experts systems. The process representation would be a frame based system with a frame for each process. Slots would contain cost of operation, retooling costs, suppliers etc. Overall system inputs would include supplier rates and desired output rates. When a user has input his particular system the software will then build an expert configurer and schedule.

IMPORTANCE TO MANUFACTURING: The flexibility of such a system will allow the representation of manufacturing systems from unit processes to plant level networks. The availability of such software will make the AI techniques available to a large community. Any change in supply output requirements or capabilities in the system would cause the expert to reschedule processes to maximize utility. Along with intelligent rescheduling the system can be used as tools for acquistion decisions.

CODE # 12

CONTINUATION OF (project title) Software Tools for System Scheduling

POTENTIAL PAYOFF (quantitative, if possible): The payoff is two-fold. For a particular manufacturing system an expert scheduler will improve product through out while minimalizing the effect of equipment malfunction and supply shortage. Moreover in developing general tools this technology becomes widely applicable.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE:

(1) Development of general knowledge representation scheme for manufacturing processes.

(2) Development of meta-system for automatic expert system building.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

(1) Development of knowledge representation scheme 1/2 year

(2) Construction of network constructing software 1/2 year

(3) Determination of meta-rules for automatic rule based system construction

(4) Integration and testing

(3)–(4): 2 years

RESOURCE REQUIREMENTS: 2 senior researchers 1/2 time for 3 years

3 graduate students for 3 years

2 AI workstations

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

APPLICATION AREA: Intelligent Information Handling

PROJECT TITLE: Expert Systems Specification and Design

PROBLEM DEFINITION/PROJECT OBJECTIVE: The objective of the project will be the identification of needs, requirements, designs and prototype of a system to support the developers of expert systems.

PROJECT DESCRIPTION/APPROACH: The project will focus upon the utilization of the ICAM developed IDEF0 and IDEF1 methodologies as the foundation for expert systems development. Special emphasis will be placed on the evaluation of IDEF1's entity/relation/attribute structure and its applicability to specifying rules and information structure for expert systems. The project will identify a methodology to integrate function and information models. The methodology will define procedures for constructing models which show classes of information common to all of the functions within an enterprise. This combination of function and information will make it possible to prototype not only the information structure but also the applications which must process the information.

IMPORTANCE TO MANUFACTURING: The experts in manufacturing are resident in the industry. Considerable resources have been spent in educating the aerospace community to the world of structured analysis and design. The MANTECH and Industrial modernization programs have placed heavy emphasis on the use of functional decomposition (IDEF0) and information analysis (IDEF1) as the methodologies for manufacturing systems analysis and design. An approach which integrates the information and functions will support rapid prototyping of many different systems.

POTENTIAL PAYOFF: A significant portion of the aerospace community is trained in the application of the IDEF methodologies to document and understand manufacturing systems. A significant number of models representing a variety of manufacturing systems have already been developed by industry experts.

APPLICATION TITLE: Expert Systems Specification and Design

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: Industry has yet to establish an easily understood methodology to support expert systems development. The development of such a system will provide topic experts an easy to use and flexible support tool to develop the rules and information structure required in the target system. This will be accomplished without the aid of a computer programmer or analyst.

PROJECT DURATION: 36 Months

MAJOR MILESTONES:

Phase I - 6 Months - Needs/Requirements Analysis

Phase II - 18 Months Design and Prototype implementation

Phase III - 12 Months Implementation and Operation

RESOURCE REQUIREMENTS: 6700 Hours Phase I
20160 Hours Phase II
9600 Hours Phase III

PROJECT CLASSIFICATION: Manufacturing Technology or Advanced Development

FOR WORKSHOP USE
CODE # 14

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

___ UNIT PROCESSES ___ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Adaptive Database Systems for Computer-Integrated Manufacturing

PROBLEM DEFINITION/PROJECT OBJECTIVE: A vital element in the data-driven automation of manufacturing will be an adaptive database system that, on the one hand, can evolve itself to respond to the changing needs or characteristics of flexible batch manufacturing and, on the other hand, can integrate into a logical whole the many heterogeneous and yet synergistic databases a CIM information system usually includes. This project will create a model facilitating the development of such adaptive systems using a data model independent architecture and an intelligent "control engine" based on AI principles.

PROJECT DESCRIPTION/APPROACH: A new Two-Stage Entity Relationship approach developed recently by the author will be employed as the basis for unification of differing data models at the conceptual level, thereby permitting an overall control of the otherwise autonomous databases. Inter-database mappings at both the external query level and the storage method level will also be supported by the construct. Decision rules will be derived from expert heuristics and analytical methods to evolve and optimize the databases according to real-time monitoring of usage. The resultant model will be tested through a pilot CIM factory being constructed; a prototype adaptive system will be developed and implemented for the testing.

IMPORTANCE TO MANUFACTURING: Inasmuch as existing database technology does not support sufficiently the development of I^2H systems in CIM settings, the proposed research will fill a critical void in the design methodology for data-driven automation. It will resolve some of the deficiencies experienced in the current manufacturing information systems, and the control engine it will provide can also alleviate the problem of system reconfiguration that is characteristic of the CIM environment.

FOR WORKSHOP USE
CODE # 14

CONTINUATION OF (project title) Adaptive Database Systems for Computer-Integrated Manufacturing.

POTENTIAL PAYOFF (quantitative, if possible): The proposed research will enhance the effectiveness of CIM databases in terms of data integrity, quality, and other performance constraints. It will also improve the system's efficiency for better respose time, greater usability, and less computing costs. But more important, through effecting the I^2H and communications the results of this project will facilitate virtually every aspect of the CIM system.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: (1) Establish a methodology for controlling and integrating heterogeneous databases without resorting to the universal single database approach that has been shown as impractical. (2)Extend the usual database concept and construct to include a decision analytic "shell" added on to the database system proper, thus set the stage for the incorporation of AI results into the system(e.g., the control engine). (3) Create a model for data-driven automation of manufacturing.

PROJECT DURATION: 3 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

(1) Comparative study of I^2H systems(field visit and literature survey)	0 - 8 months
(2) Model construction	0 - 18 mos
(3) Application of model to CIM project	10 - 18 mos
(4) Development of Adaptive database system(prototype)	16 - 28 mos
(5) Testing of prototype	26 - 34 mos
(6) Verification and standardization of model	30 - 36 mos

RESOURCE REQUIREMENTS: Computer system: LISP, 2 comprehensive DBMS's(1 relational 1 network)

1 faculty, 20% academic years 70% summers

1 research scientist in manufacturing

2 Ph.D students in manufacturing and systems

Estimated cost: $350,000.

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) ___ Exploratory Development (mid-term)

X Manufacturing Technology or Advanced Development (near-term)

FOR WORKSHOP USE
CODE # 14R

PROJECT DESCRIPTION FORM

APPLICATION THRUST AREA (please check one):

____ UNIT PROCESSES ____ MANUFACTURING SYSTEMS

X INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: Intelligent Control Adaptive Data Base Systems for Computer-Integrated Manufacturing

PROBLEM DEFINITION/PROJECT OBJECTIVE: A vital element in the data-driven automation of manufacturing will be an adaptive data base system that, on the one hand, can evolve itself to respond to the changing needs or characteristics of flexible batch manufacturing and, on the other hand, can integrate into a logical whole, the many heterogeneous and yet synergistic data bases a CIM information system usually includes. This project will create a model facilitating the development of such adaptive systems using a data model independent architecture and an intelligent "control engine" based on AI principles.

PROJECT DESCRIPTION/APPROACH: A new Two-Stage Entity Relationship approach developed recently by the author will be employed as the basis for unification of differing data models at the conceptual level, thereby permitting an overall control of the otherwise autonomous data bases. Inter-data base mappings at both the external query level and the storage method level will also be supported by the construct. Decision rules will be derived from expert heuristics and analytical methods to evolve and optimize the data bases according to real-time monitoring of usage. The resultant model will be tested through a pilot CIM factory being constructed; a prototype adaptive system will be developed and implemented for the testing.

IMPORTANCE TO MANUFACTURING: In as much as existing data base technology does not support sufficiently the development of I^2H systems in CIM settings, the proposed research will fill a critical void in the design methodology for data-driven automation. It will resolve some of the deficiencies experienced in the current manufacturing information systems, and the control engine it will provide can also alleviate the problem of system reconfiguration that is characteristic of the CIM environment.

FOR WORKSHOP USE
CODE # 14R

CONTINUATION OF (project title) Intelligent Control Adaptive Data Base Systems for Computer-Integrated Manufacturing

POTENTIAL PAYOFF (quantitative, if possible): The proposed research will enhance the effectiveness of CIM data bases in terms of data integrity, quality, and other performance constraints. It will also improve the system's efficiency for better response time, greater usability, and less computing costs. But more important, through effecting the I^2H and communications the results of this project will facilitate virtually every aspect of the CIM system.

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: (1) Establish a methodology for controlling and integrating heterogeneous data bases without resorting to the universal single data base approach that has been shown as impractical. (2) Extend the usual data base concept and construct to include a decision analytic "shell" added on to the data base system proper, thus set the stage for the incorporation of AI results into the system (e.g., the control engine). Create a data base schema to support manufacturing.

PROJECT DURATION: 5 CALENDAR YEARS

MAJOR MILESTONES (include timeframe):

(1) Identification of I^2H systems (field visit and literature survey)	0-8 mos.
(2) Model construction	0-30 mos.
(3) Application of model to CIM project	10-30 mos.
(4) Development of Adaptive data base system (prototype)	18-40 mos.
(5) Testing of prototype	36-60 mos.

RESOURCE REQUIREMENTS: Computer system: LISP, 2 comprehensive DBMS's (1 relational,1 network
2 faculty, 20% academic years 70% summers (Requirement: 1 knowledge engineer, 1 knowledge)
2 research scientists in AI 1 professional data base engineer
2 Ph. D. students in manufacturing and systems 2 Ph.D. in AI
Estimated cost: $350,000./yr. 3 undergraduate
1-780 VAX 2 -Symbolics 3-Terminals

PROJECT CLASSIFICATION (please check one):

___ Basic Research (long-term) X Exploratory Development (mid-term)

___ Manufacturing Technology or Advanced Development (near-term)

SESSION #: 3

AI/WORKSHOP EVALUATION
July 31, August 1, 1985
GROUP: 3

	CRITERIA	1	2	3	4	5	6
PROJECT #: 1	MEAN	4.47	5.60	5.27	4.53	3.33	4.20
	ST. DEV.	1.77	2.16	1.91	2.29	1.11	1.66
PROJECT #: 2	MEAN	6.07	6.93	6.73	6.73	4.27	5.07
	ST. DEV.	1.03	1.53	1.49	1.71	.88	1.53
PROJECT #: 3	MEAN	6.40	6.67	6.00	6.47	3.53	3.27
	ST. DEV.	1.30	1.45	1.46	1.30	1.13	.88
PROJECT #: 4	MEAN	6.67	7.67	6.27	7.20	5.07	5.27
	ST. DEV.	1.11	.90	1.10	1.01	1.22	1.39
PROJECT #: 5	MEAN	6.93	4.67	4.27	4.60	5.00	5.40
	ST. DEV.	1.10	1.80	1.22	1.64	1.56	1.45
PROJECT #: 6	MEAN	6.53	6.33	6.00	6.60	4.20	4.00
	ST. DEV.	1.25	1.23	1.56	1.12	.68	.85
PROJECT #: 7	MEAN	5.13	5.87	4.93	5.20	4.60	3.80
	ST. DEV.	2.56	2.23	2.46	2.48	1.59	1.47
PROJECT #: 8	MEAN	6.80	6.67	6.20	6.33	4.27	4.60
	ST. DEV.	1.15	1.63	1.57	1.63	1.16	1.06
PROJECT #: 9	MEAN	5.13	6.47	5.60	5.67	3.67	3.27
	ST. DEV.	2.00	1.96	2.10	2.53	1.40	1.16
PROJECT #: 10	MEAN	5.13	5.27	5.67	4.73	5.13	5.13
	ST. DEV.	1.41	2.05	1.99	1.98	1.68	1.51
PROJECT #: 11	MEAN	6.80	6.87	5.87	6.60	3.87	3.53
	ST. DEV.	1.52	1.06	1.19	1.59	.99	1.19
PROJECT #: 12	MEAN	6.07	6.33	5.27	5.47	4.73	4.40
	ST. DEV.	1.33	1.18	.88	1.36	.70	.99
PROJECT #: 13	MEAN	5.27	5.93	5.60	5.33	4.80	5.27
	ST. DEV.	2.28	2.31	1.84	2.13	1.26	1.62
PROJECT #: 14	MEAN	6.07	6.93	6.87	6.40	4.13	3.87
	ST. DEV.	1.44	2.02	1.73	2.03	.99	1.19

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 3

PROJECT # 1

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	1	2	4	2	3	2	Ø	Ø
2:	1	1	Ø	2	3	1	4	3	Ø
3:	1	Ø	Ø	4	5	1	1	3	Ø
4:	1	1	4	3	2	Ø	2	1	1
5:	1	2	5	5	2	Ø	Ø	Ø	Ø
6:	1	1	3	4	2	3	1	Ø	Ø

PROJECT # 2

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	1	4	3	7	Ø	Ø
2:	Ø	Ø	1	Ø	1	2	6	3	2
3:	Ø	Ø	1	Ø	1	4	4	4	1
4:	Ø	1	Ø	Ø	1	4	3	5	1
5:	Ø	Ø	3	6	5	1	Ø	Ø	Ø
6:	Ø	Ø	2	3	6	2	1	Ø	1

PROJECT # 3

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	5	3	4	2	1
2:	Ø	Ø	Ø	Ø	3	6	2	1	3
3:	Ø	Ø	Ø	3	2	5	3	1	1
4:	Ø	Ø	Ø	1	3	2	7	1	1
5:	1	1	5	5	3	Ø	Ø	Ø	Ø
6:	Ø	3	6	5	1	Ø	Ø	Ø	Ø

PROJECT # 4

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	1	1	3	7	3	Ø
2:	Ø	Ø	Ø	Ø	Ø	1	6	5	3
3:	Ø	Ø	Ø	Ø	5	3	5	2	Ø
4:	Ø	Ø	Ø	Ø	1	1	9	2	2
5:	Ø	Ø	Ø	4	9	1	Ø	Ø	1
6:	Ø	Ø	1	2	8	2	1	Ø	1

PROJECT # 5

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	Ø	2	3	4	6	Ø
2:	1	1	1	4	3	2	3	Ø	Ø
3:	Ø	1	3	5	3	3	Ø	Ø	Ø
4:	1	1	1	3	4	4	1	Ø	Ø
5:	Ø	1	1	4	4	1	4	Ø	Ø
6:	Ø	Ø	1	4	4	Ø	6	Ø	Ø

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 3

PROJECT # 6

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	0	1	2	4	4	4	0
2:	0	0	0	1	3	4	4	3	0
3:	0	0	2	0	3	3	5	2	0
4:	0	0	0	0	3	4	4	4	0
5:	0	0	2	8	5	0	0	0	0
6:	0	1	2	8	4	0	0	0	0

PROJECT # 7

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	3	1	0	3	1	2	4	0
2:	1	1	0	2	1	2	4	4	0
3:	1	2	3	0	2	2	3	1	1
4:	1	2	2	1	0	3	4	1	1
5:	1	1	1	2	6	3	1	0	0
6:	1	3	2	1	8	0	0	0	0

PROJECT # 8

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	0	1	0	5	4	5	0
2:	0	1	0	0	1	3	6	3	1
3:	0	1	0	0	3	4	4	3	0
4:	1	0	0	0	1	3	9	1	0
5:	1	0	2	3	9	0	0	0	0
6:	1	0	0	2	12	0	0	0	0

PROJECT # 9

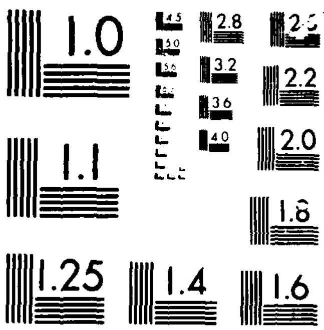
CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	1	1	2	2	4	3	1	0
2:	0	1	0	1	3	1	4	3	2
3:	1	1	0	1	4	1	6	0	1
4:	1	1	1	2	2	2	1	3	2
5:	1	2	4	3	4	1	0	0	0
6:	1	3	4	5	2	0	0	0	0

PROJECT # 10

CRIT. #	1	2	3	4	5	6	7	8	9
1:	0	0	0	8	2	0	5	0	0
2:	1	1	0	3	2	4	3	0	1
3:	1	0	0	1	6	4	0	1	2
4:	1	1	2	3	2	3	2	1	0
5:	1	0	0	2	8	2	1	0	1
6:	1	0	0	2	7	2	3	0	0

AD-A168 692 A RESEARCH PLANNING ASSESSMENT FOR APPLICATIONS OF ARTIFICIAL INTELLIGENC..(U) UNIVERSAL TECHNOLOGY CORP DAYTON OHIO W M HENGHOLD ET AL. JAN 86 3/3

UNCLASSIFIED AFWAL-TR-86-4018 F33615-83-C-5077 F/G 13/8 NL


1.0
2.8
2.2
3.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

SESSION #: 3

AI/WORKSHOP EVALUATION FREQUENCIES
July 31, August 1, 1985
GROUP: 3

PROJECT # 11

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	1	Ø	1	4	3	5	1
2:	Ø	Ø	Ø	Ø	2	2	8	2	1
3:	Ø	Ø	Ø	1	5	6	2	Ø	1
4:	Ø	Ø	1	Ø	3	2	4	4	1
5:	Ø	2	2	7	4	Ø	Ø	Ø	Ø
6:	1	1	6	3	4	Ø	Ø	Ø	Ø

PROJECT # 12

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	1	Ø	5	1	7	1	Ø
2:	Ø	Ø	Ø	Ø	5	3	4	3	Ø
3:	Ø	Ø	Ø	2	9	2	2	Ø	Ø
4:	Ø	Ø	1	3	4	2	5	Ø	Ø
5:	Ø	Ø	1	3	1Ø	1	Ø	Ø	Ø
6:	Ø	1	2	2	1Ø	Ø	Ø	Ø	Ø

PROJECT # 13

CRIT. #	1	2	3	4	5	6	7	8	9
1:	1	2	1	Ø	3	2	4	2	Ø
2:	2	Ø	Ø	1	1	3	4	4	Ø
3:	Ø	2	1	Ø	1	6	4	1	Ø
4:	1	2	Ø	1	2	2	7	Ø	Ø
5:	Ø	1	2	1	6	5	Ø	Ø	Ø
6:	Ø	1	1	2	5	2	3	1	Ø

PROJECT # 14

CRIT. #	1	2	3	4	5	6	7	8	9
1:	Ø	Ø	Ø	2	5	1	4	3	Ø
2:	1	Ø	Ø	Ø	1	2	5	3	3
3:	Ø	1	Ø	Ø	Ø	5	3	4	2
4:	1	Ø	Ø	Ø	4	1	5	2	2
5:	Ø	1	3	4	7	Ø	Ø	Ø	Ø
6:	Ø	3	2	4	6	Ø	Ø	Ø	Ø

This is an important problem, with high payoff and a very hard problem. I see no evidence of any ideas of actually how to work the problem. Just the statement "extract expert knowledge ... represent it in experts system, etc." Thus, I question the feasibility of the proposed effort.

My issue with C1 is with the use of group technology rather than other more powerful reasoning techniques for information retrieval and presentation of manufacturability advice.

Project 5

Why are iconic representations needed for much of this? The time estimate is not feasible given that one of the objectives is a national standard. Once the work is done, the standards effort will take another 2-3 years.

Developing and getting concurrence on standards is expensive and time consuming.

Project hits only a small portion of the man-machine interface problem. It is likely that icons will not become broadly used. The desire for a "standard symbology" is unrealistic.

Project 6

I don't believe the project has a great contribution to make in terms of advancement of science.

Unlike frame based rule driven inferencing techniques GT schemes essentially freeze knowledge about a domain into one efficient but rigid structure. I do not believe that development of another GT scheme is a relevant AI topic nor do I believe that an approach predicated on achieving an optimal GT system could ever converge.

Project 7

Such a product is easily within the grasp of current AI and software engineering technology.

AI as a programming paradigm is in and of itself a significant prototyping tool for software engineers.

Useful and directly applicative results are achievable in the short range with a reasonable amount of effort.

I give it a high feasibility rating because it is already being done. It seems to be an extension to work being done at MIT

There is absolutely no content in this project description to work on this important problem.

INTELLIGENT INFORMATION HANDLING RECONCILIATION COMMENTS

Project 1

The need in this area is not for hardware, but for the correct requirements. A study of what is needed at what cost is a good project. Industry could then build the hardware.

Project 2

The cost of 4 symbolics is sky high. Much cheaper computers can be used.

I doubt that it is feasible to model an "entire manufacturing capability", such as aircraft manufacturing or computer manufacturing in 3 years. The project needs a more specific focus. I doubt that there is "a generic manufacturing process".

With no group discussion and no conflicting data from the computer analysis I can find no reason to revise. The reason for the importance is the fact that little actual scheduling is done today essentially rule based dispatching is what is performed. I believe that KB techniques applied to scheduling algorithm selection and supervisor level is important.

I feel very strongly that this comprehensive project would, like HEARSAY, produce significant manufacturing and AI contributions, but will take an effort that may exceed what is listed, definitely time resources. To produce a useful result would take a large effort, at least more than 3 years, I believe.

The project is an attempt within a near-term timeframe to solve problems that are better addressed in the near-term with existing approaches. Over the long-term, the program goals make sense - but an exploratory or basic research program is different from the program described. This program will develop models and techniques that no one will use in real factories. The program could become acceptable with a reduced level-of-effort, longer timeframe and shift to exploratory development or basic research.

Wasted resources are so common and cost so much that the importance of getting a handle on them cannot be over-emphasized.

Project 3

The time estimates are unrealistic.

This is key to integrated information systems.

This project addresses a real and widespread problem. The potential user community is large enough to cause a large payoff in a short amount of time.

Massive undertaking. It appears to me to be a major software project but little theoretical development for support.

I do not clearly see the need (most tools and their integration exists). Also, how can this be made computer independent.

Project hits an important need, but it is being addressed by other means in the industry. Hard to see that this project could produce a result that is broadly applicable. Severely underestimates the difficulty of developing software tools unless the project becomes very focused. Also, no content.

Software development is too costly to be ignored in the realm of intelligent assistance. It touches every part of manufacturing and its size in manufacturing processes and systems will continue to grow. We must confine software's development costs.

A good toolbox of software development aids is critical to the success of complex software systems. End products do not materialize out of thin air, tools are needed to support the development. Also, end products will need to be tailored for each implementation site. Development tools are the mechanisms used to provide the tailoring in a cost-effective manner.

Very important and needed.

Again, this is a very important project area. I feel it was heavily criticized because of the lack of specifics and definition. I suggest review of the recent Kester Report on KB programmers assistant and I will send in some specific projects.

Project 8

The problem which this project addresses is one of the key problems which our current assessment has found with trying to use existing AI/ES development tools to explore manufacturing problems.

C2: programming language project - attempts to design a data base using logic are unrealistic
C3: object oriented programming area is well developed field using logic for data base design has been proposed years ago.
C4: I don't think the project is feasible in terms of data base design.

This is a very key project but also very difficult.

Project 9

Work in this direction is being done in the CAD Lab at MIT, at Control Data, and at FMC Corp. Capturing designer intent and relating it to functional requirements is very important.

Presumably important but I don't see the results being widely applicable. I don't see a great contribution to science and technology. Since I don't see the results generalizing, I don't expect a big payoff.

Key project - very difficult.

The problem of standards in manufacturing is being addressed through Air Force activities (IGES, PDES, etc.) and industry activities such as MAP. Another standards activity is not appropriate.

Historically, the development and acceptance of industry standards requires industry-wide participation, lead times on the order of years (e.g., 10 years), and large budgets expended by the industry as a whole. Even then, acceptance of a standard is far from assured. One exception - an industry leader, or first-with-the-technology, can sometimes impose a de facto standard unilaterally.

Project 10

I believe significant results can be achieved in much less than 10 years. Look at the Yale work with T.

I think this is an extremely hard problem so likelihood of doing it is slim. If done, it would be an achievement for AI because of the requirement that it be reliably interfaced with a real-time control system (operating system).

Not clear that this is doable in a non-hardware dependent manner. Also, I doubt the need, or at least the use of such a system if it was available.

In order to use new AI techniques and tools being developed, our operating system must be able to keep up: indeed add to the new faster, more efficient methods. If we do not prepare ourselves in the operating system area, some of our other efforts will be wasted.

The problem is payoff. I can't see this program giving significant cost savings and other direct benefits. Very exploratory. We are working this problem now without AI; can't see that using AI to find the ever-evasive "optimum" will give much incremental payoff. Also, the idea in the project is unclear.

Non-AI algorithms to handle computer queues have been in use for 30+ years. They work reasonably well. There is little payoff for successful AI here. Also, AI uses major computer resources and would slow computer operation much more than compensated by any gain in efficiency. Better to put the money into more computers and operate them stupidly - i.e., the old way.

Important and needed work.

Project 11

C1: The integration of operations research tools in the framework of an expert system is feasible and should lead to the construction of an important productivity tool.

C2: Many specific analytic tools for planning and control have been developed - utilizing these tools by managers will be facilitated by incorporating the expertise of tool experts i.e., OR experts, in the form of expert rules.

C3: There are no significant projects that I am aware of that apply expert systems to help managers carry out their decision making task.

There should be a high payoff to a project that builds on the enormous development of analytic approaches developed in the OR field - placing these tools in a DSS framework is significant.

Based on the labs IDSS experience, I consider this project under-funded.

The project is too broad and too fuzzy in its definition. It seems to be just an umbrella for developing expert subsystems and somehow tying them together. There is no real focus, thus, little hope of success.

The program is too "factory specific". Very little broad tool development. Is this not a new look at what the Air Force ICAM programs have addressed. Cannot see what will be new and lasting from this activity.

Project 12

I just don't believe there are any ideas here about what to actually do. Sounds like someone just learned about "frames" and "slots".

Project 13

The project description seems to bear no relation to the importance and payoff descriptions.

Many other heavily funded groups are working this problem in an intensively competitive R&D community effort. Given this, the proposal seems quite unsound to me.

We have used IDEF0 and IDEF2 successfully with minor modifications to support the process of building ES systems manually and I believe, with reasonable funding, that a powerful AI Dev tool could be developed.

This can be done nicely with the ART expert system tool which runs on the LMI and Symbolics Lisp machine.

Very hard problem if done correctly and completely.

It is too early to attempt to standardize development of expert systems. This project will inhibit rather than help.

Project 14

Adaptive data base systems are a good idea but the project proposes (on a minimal budget) to try to redo the IISS and multibase technology

- no new or real AI concepts.
- unrealistic expectations.

This a very important topic but I question the feasibility of solving many problems in distributed data bases in 3 years. There is already a lot of unsuccessful work in this area.

Very hard problem. Not clear new approach will solve the basic problem.

I feel strongly about importance, contribution to science, and payoff of this project. I believe this would revolutionize our capability to solve many problems.

APPENDIX D

FORMS AND INSTRUCTIONS

This appendix provides examples of the forms and instructions utilized during the preparation and workshop phases of the process. The panel specific criteria are found in the preceeding appendices and have not been reproduced here.

INSTRUCTIONS

INTRODUCTION: Although the workshop proper convenes on 31 July, it actually started with your receipt of this workbook. Your active pre-meeting participation is a key contributor to the workshop success. This section provides the details to insure a smooth flow of communication supporting the workshop.

ACTIVITIES: There are a number of activities/events that build the foundation for the workshop. These are:

- Registration: Invitees are encouraged to confirm their intent to participate by pre-registering as soon as possible. This insures that they receive all follow-on mailings required for active participation.

- Feedback and Project Generation: Each participant should provide his or her thoughts and ideas on the workshop as well as suggested project(s). Directions and blank forms are provided herein. The results of your efforts should be received at Universal Technology Corporation (UTC) by 9 July 1985.

- Feedback and Project Compilation: Inputs from participants, received by the above due date, will be compiled such that summary feedback and suggested projects can be provided to participants by 24 July 1985. This will allow a week for study prior to the commencement of group activities at the workshop proper.

FEEDBACK: This workbook was developed to provide a starting point or framework for follow-on activities. An attempt has been made to specify attainable goals and objectives, statements of challenges and opportunities, and characteristics of areas for development/application of AI methodologies to batch manufacturing. "White Papers", providing this framework, were generated by sub-panels composed of volunteer experts from industry and academia. The white papers represent an integration of ideas from many different sources and are not intended to be "position papers". It is recognized that there is room for definitional debate, disagreements as to the prime impediments to progress, etc. Your thoughts and recommendations for changes and additions are solicited. You may have a different view of the effect of technical voids, of too great or too little requirements focus, of the dangers of overenthusiastic claims of potential, etc.

You are encouraged to provide your feedback on the contents of the "White Papers" and other sections of this workbook. Your response should be typed doubled spaced on plain bond. Responses will be treated anonymously and will be integrated to a summary form.

PROPOSED PROJECT(S): Participants should provide at least one proposed project not later than three weeks prior to the July workshop. Ideas should be submitted via the project description form and according to the directions shown on page 5- . Adherence to the form provided to identify and describe the effort facilitates eventual assessment of the projects at the workshop. Submitted project descriptions should:

- Be typed on the form,
- Be limited to the space(s) provided (no attachments),
- Be prioritized by the respondent in the event he or she desires to submit more than one project.

In the event of near duplicate projects or an overabundance of proposals for a particular panel, a filtering process may be necessary. In this event, the filtering will be accomplished by ML personnel; otherwise all projects will be used as submitted.

ASSESSMENT: Projects will be assessed against established criteria at the workshop. A technique will be employed which can be viewed as an advance form of opinion survey. It has three major features:

- anonymity;
- opportunity for opinion revision; and,
- summary feedback.

Opportunity for opinion revision and information/knowledge transfer is obtained by conducting the overall survey in a series of "rounds," wherein each round the participants are allowed to provide revised opinions and/or expert information. Statistical feedback is obtained by providing participants with a summary of the responses from the previous round before asking for revised opinions or additional information. Detailed instructions concerning the assessment methodology and criteria will be provided at the time of check-in at the workshop.

CORRESPONDENCE: All correspondence should be addressed to:

Universal Technology Corporation
Research Planning Workshop
1616 Mardon Drive
Dayton, OH 43432

A Reminder - your input is needed by 9 July 1985.

CLOSURE: We recognize that the development of a program for AI applications in manufacturing is a process of iteration and refinement. We feel that the program's success hinges on the commitment evident in the past which will hopefully continue. Our thoughts are put forward in a spirit of cooperation. We are willing and anxious to listen to better ideas.

INSTRUCTIONS FOR COMPLETING PROJECT DESCRIPTION FORMS

Application Area: Check the area that, in your opinion, the proposed project best fits under.

Project Title: (limited to 15 words and must reflect manufacturing area/problem)

Problem Definition/Project Objective: Provide a statement of the problem/opportunity and the anticipated outcome or result of performing the research effort.

Project Description/Approach: Provide brief description of the nature of the research effort, and major technology areas the project focuses upon. Reference known on-going activities and explain relationships. Discuss why AI technology is applicable.

Importance to Manufacturing: Describe how this project is significant in its contribution to the desires of the manufacturing community. Consider:

- the breadth of utility across the manufacturing industry.
- the application to a variety of opportunities across unit process, manufacturing systems, or information systems as appropriate.
- how the project enables manufacturing organizations to achieve new or expanded capabilities.
- how the approach is innovative.

Potential Payoff: Describe this project's potential payoff in terms of return of current investments and/or investment in future potential capabilities. Return on current investments requires the project be truly implementable with designated deliverables, milestones and quantifiable measurements of improvement for current manufacturing needs. Investment in future potential capability provides a mechanism to research areas of uncertainty and high risk, but usually infers significantly high payoffs by providing answers to research questions. Provide quantitative measures, if possible.

Contribution to Science and Technology Base: Discuss the project's contribution to the understanding, methodologies, or tools needed to develop artificial intelligence applications for solving batch manufacturing problems. If applicable, include contributions to the education process.

Project Duration: Estimate the duration of the project in calendar years.

Major Milestones: Identify the major activities and events to measure project performance and provide calendar timeframe for them.

Resource Requirements: Estimate the resources required to complete the research effort (including the number of person-years, hardware and software needs).

Project Classification: Classify the project according to one of the following: (time is from start to potential implementation and is not necessarily the same as project duration)

- Basic Research: long-term undertakings (7 or more years) to identify and develop research base, including fundamental investigations towards the increased understanding of natural phenomena.

- Exploratory Development: medium-term efforts (4-7 years) toward the solution of specific problems including the evaluation of the practicability and feasibility of proposed solutions.

- Manufacturing Technology or Advanced Development: near-term (1-4 years) where technologies are combined to become a stage for actual production/implementation.

FOR WORKSHOP USE
CODE #__________

PROJECT DESCRIPTION FORM

APPLICATION AREA (please check one):

____ UNIT PROCESSES

____ MANUFACTURING SYSTEMS

____ INTELLIGENT INFORMATION HANDLING

PROJECT TITLE: ______________________________

PROBLEM DEFINITION/PROJECT OBJECTIVE: ______________________________

PROJECT DESCRIPTION/APPROACH: ______________________________

IMPORTANCE TO MANUFACTURING: ______________________________

FOR WORKSHOP USE
CODE # ____ ____

CONTINUATION OF (project title) ______________________________

POTENTIAL PAYOFF (quantitative, if possible): ______________________________

CONTRIBUTION TO SCIENCE AND TECHNOLOGY BASE: ______________________________

PROJECT DURATION: ________ CALENDAR YEARS

MAJOR MILESTONES (include timeframe): ______________________________

RESOURCE REQUIREMENTS: ______________________________

PROJECT CLASSIFICATION (please check one):

____ Basic Research (long-term)   ____ Exploratory Development (mid-term)

____ Manufacturing Technology or Advanced Development (near-term)

DEMOGRAPHIC FORM

PURPOSE: To provide anonymous demographic information for post-workshop statistical analysis.

INSTRUCTIONS

1. Insure that your correct ID# is entered on the form.
2. Complete the remainder of the form.
3. Return form to facilitator prior to starting the assessment round.

ASSESSMENT FORM

PURPOSE: To provide independent assessments of the project attributes based upon the criteria developed for your particular panel.

INSTRUCTIONS

1. Insure that your ID# is entered on each form you use.
2. Using your workbook as a reference for project descriptions, assess each project against the appropriate criteria. Use integer values only.

   Note - Apply your expertise for interpretation on the projects as written. You will have an opportunity to reassess during the reconciliation rounds.

3. Please use white forms for projects 1 through 15 and blue forms for projects 16 and above.
4. Return the white form to the facilitator prior to starting on the blue form.

ASSESSMENT DEMOGRAPHICS

ID# ________________

A. Please check the appropriate category corresponding to your current employment.

Academia: ____

Government: ____ Research
____ Management

Industry: ____ Aerospace Product
____ Computer Hardware
____ Computer Software
____ Non-Aerospace Product

B. Please indicate your area of primary interest in AI. You may rank order (maximum of three) if you have more than one.

____ Knowledge Representation
____ Artificial Vision
____ Pattern Recognition/Interpretation
____ Natural Language
____ Voice Recognition
____ Robotics
____ Knowledge Acquisition
____ Knowledge Based Systems (ES)
____ Other (specify) ________________________

C. Please classify your technical background.

____ Computer Science
____ Manufacturing Operations
____ Manufacturing Research
____ Knowledge Engineering
____ MATH/OR/MS
____ Engineer (specify) ________________________

Years of experience in technical background ____________

D. Does your program have active AI programs in manufacturing?

Yes ____ No ____

PREVIOUS PAGE IS BLANK

PROJECT ASSESSMENT FORM

ID#__________

PROJECT	C1	C2	C3	C4	C5
1	____	____	____	____	____
2	____	____	____	____	____
3	____	____	____	____	____
4	____	____	____	____	____
5	____	____	____	____	____
6	____	____	____	____	____
7	____	____	____	____	____
8	____	____	____	____	____
9	____	____	____	____	____
10	____	____	____	____	____
11	____	____	____	____	____
12	____	____	____	____	____
13	____	____	____	____	____
14	____	____	____	____	____
15	____	____	____	____	____

PLEASE TURN IN TO FACILITATOR UPON COMPLETION

RECONCILIATION FORM

PURPOSE: This form is provided to reconcile significant differences in individual assessments from the group mean. It is to be used for those projects where at last one criterion has been flagged on print-outs obtained prior to the feedback session.

INSTRUCTIONS

1. Please insure that your ID# is entered on each form you use.
2. Enter the project number in the space provided.
3. You may elect to reconcile/reassess in one of two ways, both of which ask you to review the basis of your assessment.

   CASE 1: If you desire to change your original assessment of a criterion or criteria (possibly based on a review of group data or a discussion), check the box labeled "1". Record your new assessment score for the appropriate criteria. Be sure you refer to the appropriate criteria scale provided to you earlier.

   CASE 2: If your assessment differed significantly from the group mean and you do not wish to change your original assessment (possibly based on your specialized knowledge/experience), check the box labeled "2". Outline your reasons/rationale for your assessment in the space provided. This information will be provided, anonymously, to the group during the next feedback session.

4. The form allows you to reconcile two projects. Please use white forms for projects 1 through 15 and blue forms for projects 16 and above.

RECONCILIATION FORM

ID#: ___________

Project Number: _____________

Additional Feedback:

(1) ______ I wish to update my assessment as follows: (use scale)

______	______	______	______	______
C1	C2	C3	C4	C5

(2) ______ I do not wish to revise my assessment for the following reasons: ____________________

Project Number: _____________

Additional Feedback:

(1) ______ I wish to update my assessment as follows: (use scale)

______	______	______	______	______
C1	C2	C3	C4	C5

(2) ______ I do not wish to revise my assessment for the following reasons: ____________________

☆ U.S. GOVERNMENT PRINTING OFFICE: 1986

END

DTIC

8-86